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Basic Principles of Concrete-Making

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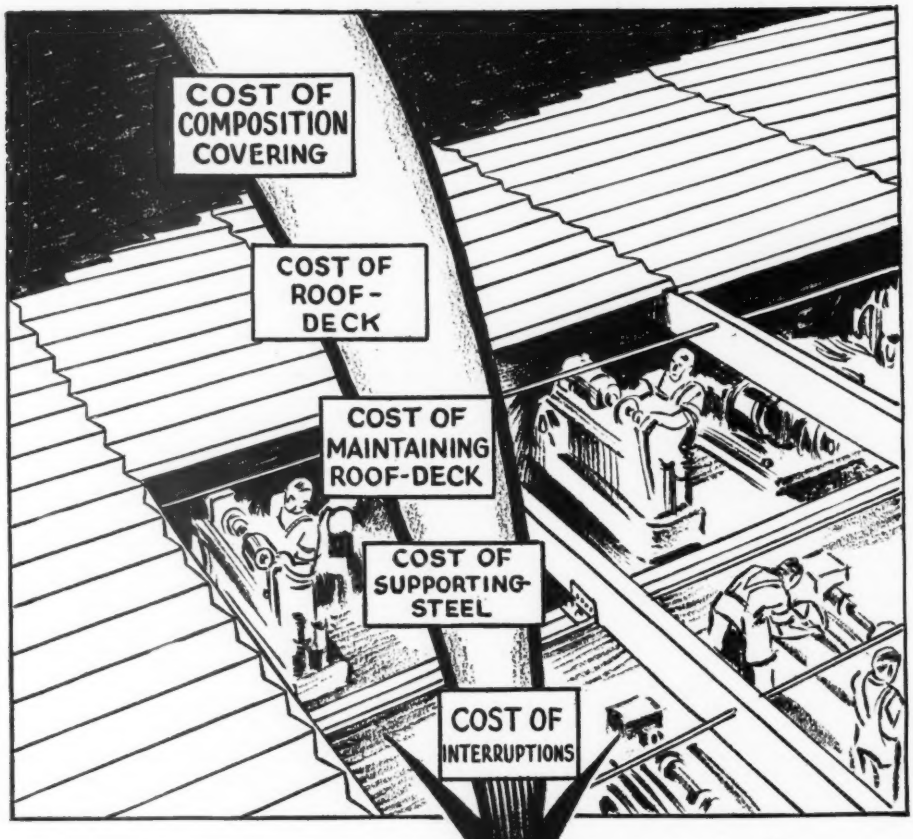

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

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Volume 102 NEW YORK, APRIL 11, 1929 Number 15

For Better Relations

THE decision of the U. S. Supreme Court in the New York rapid-transit fare case marks a long step in advance in public utility practice. Its net effect will be to improve the co-operative relations of municipal governments and public utilities. Two elements contribute to this effect: the rebuke given by the court to the interference of lower federal courts in problems to be settled primarily by state courts, and the equally definite rebuke to the attempt by the corporation to disavow a solemn contract on the basis of subtile and curious financial demands. The decision in no way places sound and efficient utility management in less favorable position; rather the opposite. But it does discourage devious legalistic attempts to justify unsound public relations.

Flood-Protection Value

FLOODS are doing their work of destruction this spring throughout the country as busily as ever. The Alabama flood of March has already set the year's record of losses at a high figure, and many minor floods increase the total. Despite the accumulating damage figures, however, nothing is done to control flood hazards, either in regions that have suffered or in others that so far have escaped, yet face the certainty of a devastating flood at the critical moment when extreme rainfall and runoff conditions shall combine. Man's age-old tendency to gamble with fate rather than guard against misfortune by timely effort is prevailingly strong. Meanwhile recent events bring forward an excellent demonstration of the wisdom of flood-protection expenditures: the experience of the Miami Valley during the late February flood. This flood, as described by C. S. Bennett, would have been severe and destructive before the valley's famous protective works were built. But the retarding basins and channel improvement controlled it and made it harmless; in this, their most severe test to date, they justified the engineers' expectations most thoroughly. Thus an undertaking of pioneer character, put through by the courage of engineering conviction in the face of much criticism and opposition, not only returns its proper dividends to the communities for which it was carried out but also places before the entire country a shining example of the value of flood protection.

Hydrostatic and Hydraulic Dangers

POSSIBILITIES of water uplift on dams are illustrated in an instructive way by the Baltimore filter basin accident, where a dividing wall failed a week ago. In its essential service the wall was a dam, at least when one of the basins was empty, which was the contingency for which the wall was built. Uplift and flotation are clearly manifest in the behavior of the broken and displaced sections; practically without injury to its structure except for separation at construction joints, the wall was pushed sideward a large distance. Profiles and views reveal a lifting and skidding effect. Since some rock came up with the wall, adhering to its base, and since the valuable eyewitness report proves the existence of decided and rapidly increasing seepage just before the failure, it is probable that some part of the failure resided in the rock under the wall and is to be attributed to the entrance of water into parting planes within the rock, resulting in the development of uplift or bursting pressure. That this type of failure can occur has been recognized for a long time, but it received an interesting emphasis in a paper recently read by Prof. Charles Terzaghi before the Institute of Mining and Metallurgical Engineers. He was led to conclude that such failure need not develop instantaneously, but may require days or even many months before the water penetration and flow develop their full effect. The T-shaped wall at Baltimore is clearly subject to destructive uplift if water can find its way under the unloaded toe and develop any material uplift, but the condition is even more complex in view of the possibility that water may enter into rock seams lying below the base, thereby developing uplift over a larger area than the base of the wall alone. The situation involves not merely hydrostatic considerations but also geological and hydraulic ones. They suggest that the selection of type of dam for service as basin-dividing wall may call for particularly careful study when proper underdrainage is not readily feasible or when it will not protect against pressure heads within the rock strata.

Rails to Hudson Bay

FOR YEARS the farmers of the prairie provinces in Canada have been demanding that they be given an outlet for their grain by the short route to Europe through Hudson Bay. Before the war the building of a railway to the bay was urged upon the dominion Parliament session after session with such insistence that just before the outbreak of war work was begun upon the construction of the railway and of a port at Port Nelson. The war put a stop to the work, but the demand continued and recently it was undertaken again. Under the revised project Port Nelson was abandoned as a terminal because of the unsuitability of the site. Within the last few weeks the rails have been laid to the site of the new port at Fort Churchill. It remains now for the track to be made safe and the port and grain storage facilities to be built at Fort Churchill before grain can be shipped from that port. Whether grain *will* be shipped in quantities to make the port of value to its builders is another question. Ever since the Hudson Bay route was proposed, discussion has raged over whether or not ships could navigate Hudson Bay and the straits leading to it during a long enough period of time to make the route practical. Proponents of the route claim that it is open from midsummer to fall; opponents claim it is seldom free from

ice for more than two or three weeks. At best, the navigation season will be short and only experience can tell of what value the Hudson Bay Railway will be as an outlet for grain to Europe. The odds appear to be against it. Fortunately, however, the present indications are that its construction, opening up as it does a vast area having great possibilities in the way of mineral resources, may yet return a profit to the Canadian government.

A Significant Record

SIGNIFICANT facts are brought to light in the record of events incident to cable wire breakages at the Mount Hope suspension bridge set forth on another page. The engineering world may well feel indebted to the engineers for making the record available promptly and fully. It shows that the wire breakage was a progressive happening, something which evidences a mysterious time factor in the failure of the metal. First of all this progressive effect is evident in the sequence of events at the Bristol east anchorage, where wires continued to break during a two weeks' period of frequent and meticulous inspection after breaks were first discovered in considerable number. While there is some room for believing that the additional breaks here may have resulted from gradual redistribution of load among the wires as one after another went out of service, the argument is not very satisfying. That breakages began at the Portsmouth east anchorage fully two weeks later is subject to a similar counter-argument. But the case is placed beyond doubt by the Portsmouth west cable breakages. Substantially all of these occurred after the first trouble developed in the opposite cable and during a period when the load on the structure was decreasing; they cannot well have been induced by the weakening of the east cable, nor by any increase of demand placed on the cable, but represent spontaneous failure under steady, quiescent load, a load which the cable had borne for weeks without injury but which finally produced a break. Such behavior of steel is new in structural history; nothing resembling a time effect of loading has been previously observed, even at full working stress, let alone at the very low stress which the cables bore at the time they failed. It is to be remembered, of course, that no structures heretofore have used a hardened and tempered spring-steel wire, cold bent as was this cable wire at the place where the breaks occurred. It remains to be seen whether the cables in removal will show any breaks elsewhere in their length, and it also remains to learn fully the physical conditions and the circumstances under which the breaks can be duplicated. Full research into the behavior of the steel is a problem of most pressing urgency.

Notable Plant Engineering

MASS production of concrete for the Hudson River bridge anchorage offered a subject for plant analysis of a superlative character. There was 106,000 cu.yd. of concrete to be placed, at the rate of about 12,000 cu.yd. a month if full contract time were taken. The schedule was set some 2,250 cu.yd. a month higher and as a matter of fact there was produced each month more than 19,000 cu.yd. of finished concrete in place. Some 200,000 tons of material had to be handled a distance of 1,000 ft. horizontally and 225 ft. vertically all in nine months—actually it was handled in five and a half months. This will indicate the magnitude of the plant and operating problem. The selection of belt-conveyor transport was based on very careful comparisons of all available methods. The engineering study that was devoted to this installation of equipment for at most nine months' use would have been creditable in designing a permanent bridge of considerable magnitude. But the greater engineering accomplishment was in plant operation. With four conveyor units, a gravity twin-mixer plant unit and a tower hoist and chuting unit to be operated in close conjunction, there was a pretty task in synchronized operation to be accomplished. As the plant took on its work every function was timed and studied and those causing the sequence to lag were speeded up and brought into co-ordination; it was quite like the tuning up of a great power plant.

Regional Tying In

HOW to tie in planning for regional engineering work with some governmental agency is one of the great problems of the day. Thus far most regional planning has been done by voluntary agencies, with no governmental powers. Formulated independently of any governmental agency, regional plans are more likely to be ideal than practical. They lack tie-in with both physical and political realities. They gather dust and are forgotten.

To insure execution of regional plans there must be a living, continuing force behind them. When the plans antedate such a living force, its creation is beset with difficulties, while if the force creates the plans their execution is more than half assured. If the region is within a single county and if the county is more than a shadow (such as a minor court agency), regional planning and engineering may become integral with county government, just as city planning is sometimes integrated with city government.

An instructive illustration of regional planning, with some degree of execution, is afforded by the article on the Milwaukee region, elsewhere in this issue. In this case regional planning work is headed by the county highway commissioner, making a close tie-in with the county's major highway program. Co-operation with the county park commission is also notable. Beyond these lines, zoning and subdivision platting have been the other notable features of the planning work, two basic elements in county as in city planning. Trunk sewers and sewage disposal are otherwise cared for, as is water supply. Indications elsewhere are that these may often be left to special districts, rather than be conducted as county or county-region enterprises; often, as in Milwaukee County, by extensions of the water service of the major city in the county or region.

Two facts deserve special attention in connection with the present phase of the subject. The first is that conditions favor regional planning and construction by the government of Milwaukee County, because the counties have broader powers in Wisconsin than in other states and because, as a state, Wisconsin has not feared innovations and has been liberal as to home rule. The other fact is that effective regional planning is possible here within the confines of a single county. This is also true in some other regions but far from true in many cases, where the region may cover several counties in two or more states. A governmental agency to meet such planning conditions, at the same time tying them into construction, without which regional planning is more or less futile, is the problem of the next few years.

Basic Principles

FOR some time back the concrete-making art has been floundering in certain respects. While on the whole advancing, it has done so with uncertain and sometimes retrograde steps. Excellent concrete has been made, and also very bad concrete. A dam in the West leaks uncomfortably, though built with the aid of what was believed to be the most refined scientific effort to produce a mixture of ideal excellence and economy. A dam in the East is scaling and crumbling on its surface, though only a few years old. A bridge whose construction was scientifically supervised so that it might be not only strong but of perfect appearance turned out to be blotchy and honeycombed when the forms were stripped.

There is a reason for these conditions: the art has been made too complex. The belief has grown up that intricate charts, formulas and slide rules are necessary preliminaries to the production of good concrete. Inherently the art is as simple as it was many years ago, when it was clearly understood that the necessary and sufficient ingredients of concrete are cement, sand, stone and water, together with common sense and judgment; but recent practice has tended away from this simplicity. For example, on one important undertaking the field engineer devoted his major attention to sampling the successive shipments of gravel and sand, screening and sieving the samples, making careful computations to determine how they should be mixed, and finally finding by trial how little cement and water he could add to this mixture and yet meet a certain slump requirement. If good concrete is obtained in spite of such involved procedure, it is only by good fortune and excellent field judgment.

In short, fineness modulus, surface area and like devices have badly bedeviled an art that at bottom remains intensely practical despite its scientific foundation. It is timely that these conditions be corrected by a return to simplicity of understanding and practice. To put this within easy reach is the objective of F. R. McMillan's articles on "Basic Principles of Concrete-Making."

With brilliant clearness of view the author has reduced the subject to its fundamentals; and in so doing he has written a document of long-time value. For the complex theories and rules of the recent past he substitutes a simple statement calling for two steps: first, the selection of a cement paste of a known degree of wetness, which according to Abrams' well-known law predetermines the qualities of the final concrete; and second, the addition of sand and stone in amounts that will fill this paste as thoroughly as possible and produce a fully plastic, workable mass. Note the significant last clause; its full meaning, emphasized farther on, carries the key to the statement of concrete doctrine. Nothing could be simpler. And a striking feature of the matter is that practical field judgment appears to be the best (if not the only) guide in deciding on the second step. Thus the practical concrete man returns to his own, but with greater power; instead of having to depend on unaided experience he now has a definite yardstick by which to rate his material—namely, the water content of his paste.

Perhaps one of the points of greatest value of the entire doctrine is that it tends to restore the field worker's confidence in his practical judgment. It shows him that his intuitions still are valid, and that he therefore has a real responsibility for results in the quality and appearance of concrete.

It is worth noticing that the new statement of principles is derived from a new conception of concrete-making. In the past it has been customary to conceive of concrete as something produced by taking a mass of aggregate and filling its interstices with a mortar, which in turn was produced by taking a mass of sand and filling it with cement. The conception on which Mr. McMillan bases his statement of principles is the reverse of this: a batch of paste of fixed water ratio is prepared, and the aggregates are then embedded in the paste. The new conception is as significant in its practical application as it is logical in its relation to the chemical and mechanical factors involved.

In reading the statement of principles some associated facts will occur to anyone who follows the author's exposition closely. One of them is that workability will not always mean just the same thing; its meaning will vary slightly with the conditions of placement—though, of course, it may never be stretched to include a distinctly wet mix, nor a dry mix except when thorough tamping or equivalent mechanical consolidation is to be used.

Another and even more important fact is that, after all, the most suitable wetness of the paste and the best amount and grading of the aggregates are not independent variables. They influence each other markedly. But any attempt to evaluate both variables by one single step is likely to fail in practice. One of the two variables must be fixed upon first, at least tentatively, and the other then determined from it, subject perhaps to a readjustment on second trial. In the practice of recent years the attempt was usually made to determine first the aggregate combination. Mr. McMillan by reversing this practice makes what seems almost a stroke of genius—but after all something eminently sane and sensible, since it begins the concrete-making process with the active element, the cement paste, to which the aggregates serve only as diluents and as body-forming additions.

One term bound up in the statement of principle is perhaps more important than any other: the term *plastic homogeneous mixture*. So soon as the reader has thoroughly grasped the significance of this term he will be beyond danger of missing the author's essential instruction. A plastic and homogeneous mixture is freely but sluggishly mobile, is full throughout, and is proof against segregation so far as the immutable laws of gravity permit. Such a plastic mixture will make uniformly good concrete, of properties determined by the degree of moisture of the paste. That, in brief, is the doctrine of the articles.

It remains to add that of course there are differences between cements; that aggregates differ; that grading is not without vital meaning; and above all that mixing, transporting, placing and curing must be done with care and excellence. All these are vitally important matters, but they are matters which the able engineer and concrete-worker will find no difficulty in handling.

Be it understood that the articles do not purport to set forth all the facts and secrets of concrete, neither of the present nor of the probably much greater future; they do, however, go far toward eliminating some of the mystery that has come to surround the subject, and they simplify effectively the principles of proportioning. In future we shall doubtless know much more about watertightness, strength, plasticity, texture and control of properties. But regardless of such advances, the basic principles now set forth are likely to remain fundamental.

First of a Series of Five Articles

Basic Principles of Concrete-Making

A Statement of the Fundamentals Which Govern the Properties of the Composite Material, Showing in Simple Form How to Select and Combine Its Ingredients

By F. R. McMillan

Director of Research, Portland Cement Association, Chicago

I—Cement Paste the Basis of Concrete Quality

Editor's Preface

More than a year ago Engineering News-Record *asked a leading student of concrete, "Can the principles of proportioning be put in simple terms, and the rapidly growing complication of the subject cleared away?" Shortly afterward several actual field cases of concrete structures which proved defective, despite an honest effort to carry out some of the complex theories, showed that there was good cause for the query. Accordingly Franklin R. McMillan, to whom the question was addressed, agreed to set down the basic principles in clear, simple and practical form. The result of a year's work on this task is the present series of articles.*

THE purpose of this series of articles is to present the underlying principles of concrete mixtures and to provide a simple working basis for applying these principles to the production of concrete to meet the definite requirements of a particular structure. Special consideration will be given to the requirements for durability, both in the selection of proportions and in the control of the other factors which influence the life of a structure.

To provide continuity of thought and to clarify the issues, there will be presented first a brief résumé of a philosophy of concrete mixtures which recognizes the cement paste and the aggregates as the two component materials in concrete, and a statement of the method of mixture design based on this philosophy. Following this will be given the supporting data and a full discussion presenting the many considerations which are essential to the economic production of durable structures. Of necessity this résumé must be direct and brief. If the reader finds statements in seeming contradiction to his own experience, he is urged to withhold judgment until the supporting data are examined, for it is believed that every statement will be substantiated.

Cement Paste the Basis of Concrete Quality

Expressed in the simplest terms, concrete is a mass of aggregates held together by a hardened paste of portland cement and water. The distinction between these two elements of concrete should be kept clearly in mind. The aggregates are essentially inert. *The paste is the active element.*

There are, of course, certain properties of the aggregates which influence the properties of the concrete; these will be brought out later in this study. But at this point it is necessary only to observe that, important as these properties are, they should not be allowed to obscure the fact that the concrete derives its useful properties mostly from this hardened cement-water paste.

Hence we must first understand the paste. Clearly, if strong concrete is desired, the paste must develop high strength when hardened. If watertight concrete is required, the hardened paste must itself be watertight.

Properties of the Cement-Water Paste—When portland cement is mixed with enough water to form a paste, the compounds of the cement react with the water to form new compounds which adhere to each other and to the aggregate particles to form the binding medium which gives concrete its useful properties. These chemical reactions require (1) time, (2) favorable temperatures and (3) the continued presence of water.

A cement paste in which the reactions have progressed only slightly (whether due to low temperatures, to insufficient time or to loss of water from the mass) cannot have the strength or watertightness of one in which the chemical changes are more complete. Thus, age and curing conditions become essential factors in the quality of the hardened paste. Likewise, those characteristics of the cement which influence the rate of chemical combination are factors. Some cements gain their strength more rapidly at first, while others show greater increase for longer periods.

Another factor in the quality of the hardened paste is the relative proportion of cement and water. This obviously affects the properties of the paste just as the properties of mixtures, alloys, or other combinations of materials are affected by the proportions of the ingredients. Only a certain amount of water can be combined with the compounds of the cement, and any water in excess of this amount dilutes the mixture and reduces its potential strength, watertightness and durability.

Thus it is seen that the properties of the hardened paste are dependent upon these three factors:

1. The characteristics of the cement.
2. The relative proportions of cement and water.
3. The completeness of the chemical combination between the cement and water.

It is through the control of these factors that the engineer can control the ultimate usefulness of his concrete structures.

Combination of Aggregates and Paste—When the aggregates and cement paste are mixed to form concrete, the space between the aggregate particles must be completely filled with the paste. Further, as a practical matter the paste must be of such consistency that the mixture is plastic and remains homogeneous during transporting and placing.

With clean, impervious aggregates, such a mixture will give a concrete in which the permeability is determined

by the watertightness of the hardened paste. If, in addition, the aggregates are themselves of durable mineral composition, the resistance of such a concrete to weathering will be determined largely by the resistance of the hardened paste to weathering. Also, the strength of such a mixture will be determined by the strength of the paste unless the aggregate particles themselves are weak or of such a character as to offer little bond with the paste.

The problem, therefore, of proportioning concrete for a given purpose consists of two steps: first, the selection of that proportion of water and those conditions of curing which, for the given cement, will give a paste to meet the requirements for the particular structure as to strength, watertightness or weather resistance; and second, to find such a combination of aggregates as will give a mixture that is plastic and that will remain homogeneous during placing and through the setting and hardening period.

Importance of Plastic and Homogeneous Mixtures—It is vital throughout this discussion to keep in mind the necessity for plastic and homogeneous mixtures.

A plastic mix is one which can be readily molded but which changes form slowly when the mold is removed—that is, it flows sluggishly but without segregation of the water or the fine materials from the coarse. With such a mix, it is possible to produce a homogeneous mass so that every portion will be exactly like every other portion; only then can the laws of strength and watertightness of the cement paste be applied to the concrete as a whole.

The plasticity of a mixture is governed by the following factors:

1. Relative quantities of paste and aggregates.
2. Plasticity of the paste.
3. Grading of the aggregates.
4. Shape and surface characteristics of aggregate particles.

For any given paste, decreasing the amount of paste with respect to the quantity of aggregate stiffens the mixture, and increasing the amount of paste renders the mix more fluid. Similarly, for a given quantity of paste and aggregate, the plasticity of the mix will depend upon the relative quantities of cement and water in the paste. A paste that is high in cement and low in water content will itself be stiff and cannot carry much aggregate without becoming so stiff as to be wholly unplaceable. On the other hand, if the cement content of the paste is low and the water content high, the paste may be so thin and watery that it will be unable to hold the aggregates in that cohesive mass which is the very embodiment of plasticity.

The grading of the aggregates affects the plasticity of the concrete, *first*, by affecting the quantity of paste necessary to fill the spaces thoroughly and surround the aggregate particles completely, and *second*, by affecting the resistance which is offered to the mobility of the mass through the varying combinations of sizes.

As in the case of grading, the shape and surface characteristics of the particles affect the plasticity of the mix through their effect on the amount of paste required and on the friction between the particles as the concrete is molded. Angular particles or those with rough surfaces require a greater amount of paste for the same mobility of mass than is necessary for well-rounded particles or those with smooth and slippery faces, other conditions remaining the same.

Wet and Dry Mixes to Be Avoided—The importance of plastic mixes, as a factor both in the construction operations and in extending the useful life of the structure, cannot be overemphasized. For proper placement, it is essential that mixes be of such plasticity that they can be molded readily into the corners and angles of the forms with the assurance that every portion of the space will be thoroughly filled with the concrete and that there shall be no honeycombing in the mass. Thus, dry, non-mobile mixtures which are difficult to place must be carefully avoided, both as a convenience in placing and to assure a uniform and homogeneous mass in which all the space between the aggregate particles is filled with a cement paste of the desired quality.

Equal care must be taken to avoid the overwet mixes. While mixes of this type are easily placeable and therefore all too commonly used, they are a serious menace to the life of a structure exposed to the weathering action of the elements. The segregation of materials in handling in such mixes causes honeycombed spots which offer the first point of attack for water and frost. Also, the accumulation of water and fine materials at the surface as the placing of such mixes progresses results in laitance layers and porous concrete immediately below. These are the causes of the most widely observed form of disintegration.

Many have formed the impression that the present-day agitation for the control of the quantity of mixing water necessarily means dry, unplaceable concrete. Nothing could be farther from the truth. This misconception arises largely from the habit of thinking of concrete solely in terms of certain arbitrary proportions, in which case, of course, any change in the water content is accompanied by a change in consistency. Once the habit of relating all discussions of concrete to experience with 1:2:4 or other fixed proportions is thoroughly shaken off, it is seen that *control of the quantity of water means simply fixing the potential quality of the concrete*. Thus, with the water quantity fixed in terms of the cement, the consistency must be controlled through the relative quantities of aggregate and paste and proportion of fine to coarse aggregate. Naturally, the consistency to use depends upon the requirements of the work; the concrete should be sufficiently mobile to mold properly, but not of such fluidity that the material will segregate either in placing or through settlement after once in place.

Combined and Uncombined Water

Some of the relationships above outlined can be pictured more effectively by a diagrammatic study of the relation of water to the finished concrete. It is necessary to consider separately the combined and the uncombined water.

Fig. 1 is a diagrammatic representation of the separate constituents of a series of concrete mixtures. The lower diagram represents five mixtures, 1:1:2, 1:1½:3, 1:2:4, 1:2½:5, 1:3:6, with respective water-cement ratios of 4½, 5, 6, 8 and 10 gal. per sack. These particular mixes give a fairly regular variation from rich to lean concrete and have the same consistency—namely, a slump of 3 to 4 in. While it is not possible to have mixes varying through this range in cement content with exactly the same degree of placeability, it can be seen that for certain types of work, as for example a massive wall or dam, these mixes could each be used satisfactorily. In this illustration it is assumed that the mixes have been properly placed to avoid separation or segregation of the ingredients. This is of utmost importance, as will be brought out frequently in these articles.

TABLE I—QUANTITY OF COMBINED WATER AS AFFECTED BY QUANTITY OF MIXING WATER AND AGE

Cement 1. Water Retained in Paste When Dried at 239 deg. F.

Mixing Water, Gal. Per Sack	Water Retained in Dried Paste in Per Cent of Dry Cement Moist Cured Until Test								
	1d.	3d.	7d.	14d.	28d.	3m.	6m.	9m.	1y.
3.38	4.1	6.3	8.3	8.8	9.7	10.6	11.0	11.6	12.6
5.08	5.0	7.7	9.8	10.5	11.7	13.0	14.0	14.7	16.2
6.77	5.7	8.6	10.8	11.7	13.0	14.6	15.9	16.8	18.5
8.43	6.2	9.2	11.5	12.6	13.9	15.8	17.0	18.2	19.9
10.2	6.6	9.6	11.9	13.3	14.4	16.7	17.7	19.0	20.8

TABLE II—QUANTITY OF COMBINED WATER AS AFFECTED BY TEMPERATURE OF DRYING

Cement 1. Mixing water, 60 per cent by weight (6.77 gal. per sack). Paste dried in air at temperatures shown.

Temperature of Drying, Deg. F.	Water Retained in Dried Paste, Per Cent of Dry Cement			
	1d.	7d.	28d.	1y.
122	9.7	15.5	18.9	24.8
194	7.5	12.2	15.0	20.1
212	6.5	11.7	14.1	19.1
239	5.7	10.8	13.0	18.5
302	5.4	10.1	11.8	14.9
392	5.0	8.8	10.5	12.9

TABLE III—QUANTITY OF COMBINED WATER AS AFFECTED BY DIFFERENT CEMENTS

Cements, all standard portland cements. Mixing water, 60 per cent by weight of cement (6.77 gal. per sack). Pastes dried at 239 deg. F.

Curing Period Moist	Water Retained in Dried Paste, Per Cent of Dry Cement			
	Cement 1	Cement 2	Cement 3	Cement 4
3 days	8.6	8.2	8.5	7.6
7 days	10.8	10.8	11.2	9.6
28 days	13.0	12.6	13.1	12.1
1 year	18.5	16.8	18.4	16.1

The abscissas of this diagram have no significance. The mixes are merely spaced equally. The ordinates of the lower diagram represent the absolute volumes (volumes of solid matter) of the ingredients in a unit volume of freshly mixed concrete. The 1 : 1 : 2 mix, for example, is seen to consist of 66 per cent aggregate, 16 per cent cement and 18 per cent total water, and the 1 : 3 : 6 concrete, at the opposite side of the diagram, of 76 per cent aggregate, 6.7 per cent cement and 17.3 per cent total water. These figures ignore the small air voids that are apt to occur, as in these mixes they are negligible. For mixes of stiffer consistency or with a very high proportion of fine aggregate, the air voids might be of such magnitude as to require their inclusion. This matter of air voids will receive separate consideration later in the series.

The noteworthy feature of the lower diagram is the relative quantity of aggregate, cement, combined water and uncombined water for the different mixes. Thus, note that the total quantity of cement and aggregate is quite uniform in the five mixes; it follows, therefore, that in order to produce a fixed consistency (3 to 4 in. slump in this case) about the same total amount of water is required per unit volume of concrete for rich and lean mixes alike. This shows the intimate relation between cement quantity and water ratio. For a fixed proportion of fine to coarse aggregate, any change in the quantity of cement must be offset by a change in the water quantity to maintain constant consistency. This whole matter is of great importance and will be more fully considered later.

Amount of Combined Water—The most significant relation exhibited by the lower diagram of Fig. 1 is the proportion of combined and uncombined water with respect to the other elements of the mix. The quantities of combined water which were plotted in the diagram are those which would exist at one particular age and under a particular set of curing conditions.

The quantity of combined water may vary over a wide range, being influenced by the fineness and composition of the cement, the quantity of water mixed with the cement, the age and curing conditions. Water which remains in the concrete in some degree of fixity at one temperature and humidity passes off readily at some higher temperature or lower humidity. Tables I, II and III give some data from studies by Raymond Wilson now under way in the Research Laboratory of the Portland Cement Association, showing a possible range in the amount of combined water. The quantities of water retained for the different conditions of test are expressed in percentages of the cement by weight.

In Fig. 1, the quantities of combined water assumed are 12.6, 14.0, 15.0, 16.2 and 17.4 per cent of the weight of the cement for the five mixes from left to right. This increase in combined water with an increase in water-cement ratio is in accordance with the data quoted from Wilson's tests. It can be seen by a study of Tables I, II and III that these allowances for Fig. 1 represent about 28 days' moist curing if the basis for fixing the combined water is assumed as dry air at 120 deg. F.

If Fig. 1 is studied in the light of the foregoing discussion, it will be easy to see how the watertightness of the concrete is so closely related to the quantity of mixing water and the extent of the curing. This is made particularly apparent through the upper diagram, in which each ordinate represents a unit volume of the paste from the corresponding mix in the lower diagram. Comparing the rich mix at the left with the lean mix at the right, it is seen that in the former 36 per cent of the volume of the paste is represented by uncombined water, while in the lean mix the combined water is 60 per cent

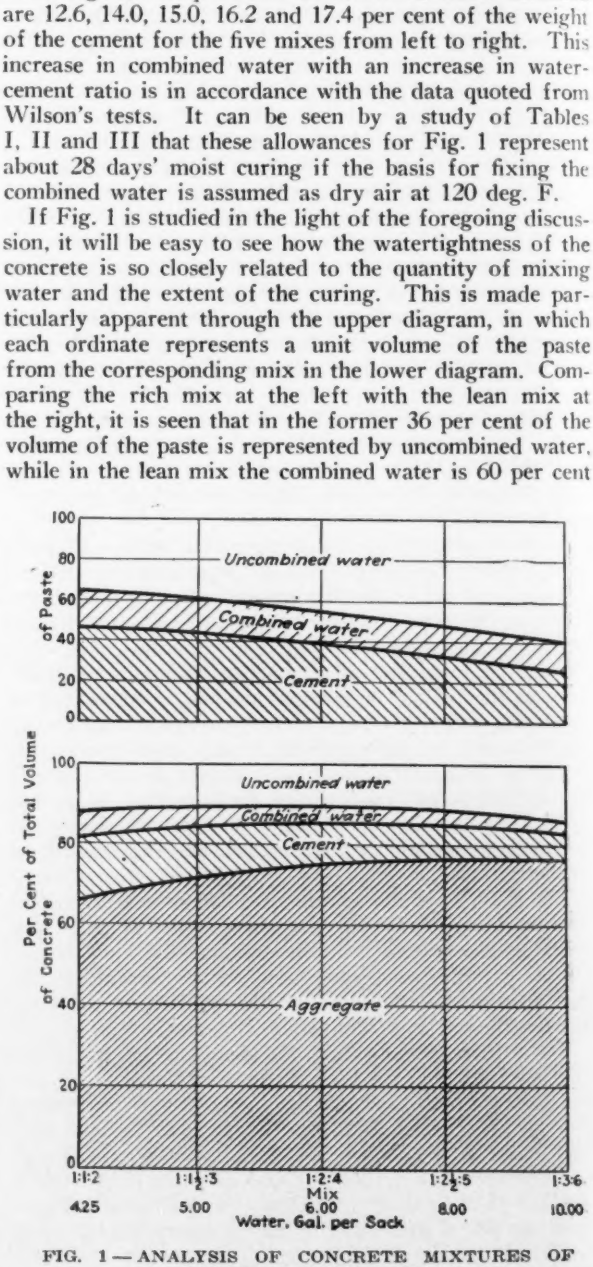


FIG. 1—ANALYSIS OF CONCRETE MIXTURES OF UNIFORM CONSISTENCY

Slump 3 to 4 in.

of the volume. The effect of this difference on the watertightness of the paste is even greater than the percentages indicate. The size of the individual pore spaces in which this uncombined water is held also affects the permeability, for the flow of water under pressure is materially impeded by a reduction in size of the channel. The rich mix, therefore, with its smaller total volume of pores distributed through a larger mass of paste, will have a decided advantage over the lean mix, with a larger volume of pores distributed through a smaller paste volume.

The preceding passage is concerned only with the spaces occupied by uncombined water. Air voids and honeycomb, where they occur, would obviously alter the leakage relations.

The vital influence of curing on watertightness can also be visualized from the upper diagram of Fig. 1. Suppose, for example, that, by more thorough curing, the quantity of combined water be made twice as large as that indicated. This would give a proportion of pore space to total paste volume of 19 per cent for the rich mix and 46 per cent for the lean.

Minimum Quantity of Cement—Fig. 1 will also be found to show that there is a lower limit to the quantity of cement below which watertight concrete cannot be expected. The diagrams reveal at once that, as the cement quantity decreases from the rich toward the lean mixes, the water-cement ratio necessarily increases so that the proportion of pore space in the paste increases. Since the amount of combined water is evidently related to the quantity of cement, no amount of curing can add enough water to the solid volume of the very lean mixes to overcome this deficiency in cement. Even though a certain aggregate combination may be highly favorable (by requiring less paste than another), the concrete cannot develop a high degree of watertightness unless it contains enough cement to permit an effective building up of the internal structure through curing. For a guide as to the water-cement ratio permissible, we must look to past experience, together with such additional information as brought out by tests. Later, suitable limits for different classes of work will be indicated.

The data supporting the philosophy just developed will be presented in the next article.

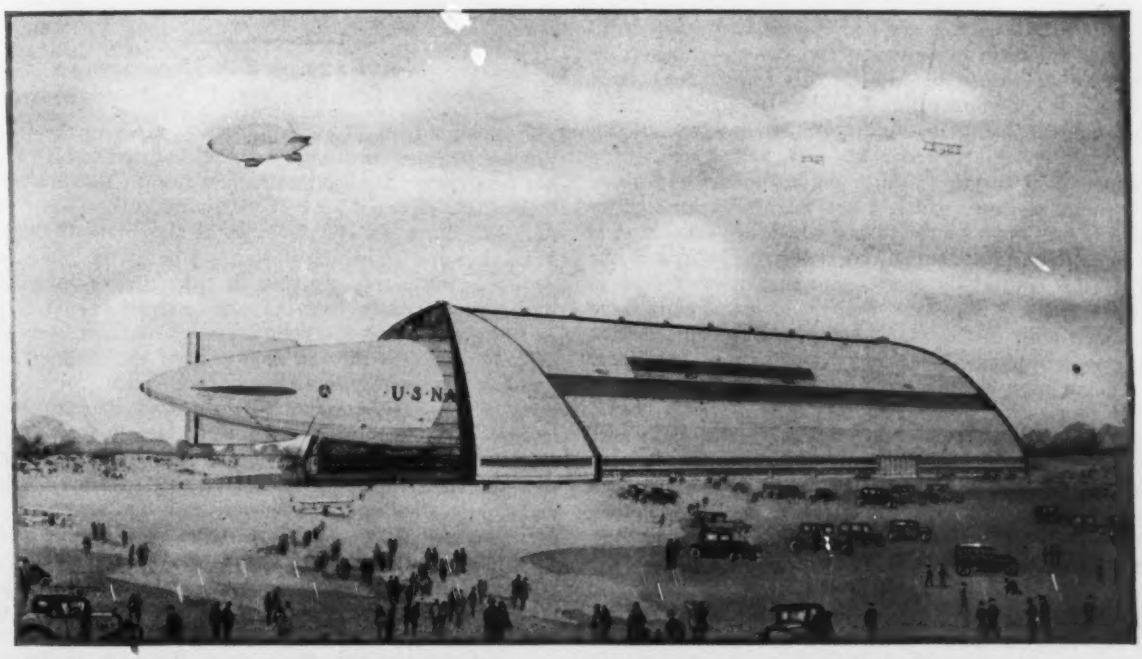
Mr. McMillan's second article will appear April 18.

Huge Airship Factory at Akron Under Construction

Parabolic Structure 1,175 Ft. Long and 205 Ft. High to Rank as World's Largest—To Be Used as Shop for Building Dirigibles

AN AIRSHIP dock, or hangar and manufacturing building, considerably larger than the one at Lakehurst, N. J., used as the home of the U. S. Navy dirigible "Los Angeles," is being built for the Goodyear-Zeppelin Corporation at the Akron, (Ohio) municipal airport, about 3 miles southeast of the city. The structural frame differs from other airship docks in this country in that it consists of a series of arch trusses giving to the shell an approximately parabolic cross-section. The doors, too, which are spherical in shape, differ radically from those used on other airship docks in the United States. In order to prepare the site for use, much grading has been necessary, the total amount approaching 1,000,000 cu.yd. Involved also in the construction of the building are 7,000 tons of steel, 1,300 concrete piles and about 10,000 cu.yd. of concrete.

The foundations are now under construction and are so placed that the longitudinal axis of the building will coincide with the direction of prevailing winds during flying weather. In size the structure exceeds any other airship dock yet built either in this or in a foreign country, and also has the distinction of covering the



ARTIST'S DRAWING OF AIRSHIP FACTORY AND DOCK UNDER CONSTRUCTION AT AKRON, OHIO, MUNICIPAL AIRPORT

largest single floor area ever placed under one roof, this area being approximately 389,000 sq.ft. The structure will be 1,175 ft. long, 325 ft. wide center to center of arch pins and approximately 200 ft. high. The largest airship dock now built is that at Karachi, India, one of the several for the England-India service, which has a length of 850 ft., a span of 230 ft. and a clear height of 170 ft. The reinforced-concrete hangars at Orly, France, have a length of 984 ft., a span of 298 ft. and a height of 194½ ft.

The largest airship docks so far constructed in the United States, and in fact the only ones of any considerable size, are the navy hangar at Lakehurst, N. J., and the army hangar at Belleville, Ill., known, respectively, as the Lakehurst hangar and the Scott Field hangar. The former, the home of the "Los Angeles," the largest dirigible at present owned by the United States, has a length of 803 ft., a span of 264 ft. and a height of 172 ft. to the upper pin. The hangar at Scott Field has a length of 810 ft., a span of 150 ft. and a height of 150 ft.

Since the new Akron factory and dock is to be used principally as a manufacturing building, its size was largely determined from the dimensions of the two new ships, the "ZRS4" and the "ZRS5," now under contract to be built by the Goodyear-Zeppelin Corporation for the United States government. Some idea is obtained of the size of these new dirigibles by comparing their gas capacity of 6,500,000 cu.ft. with the 2,600,000 cu.ft. capacity of the "Los Angeles" and the 3,707,550 cu.ft. capacity of the "Graf Zeppelin." It is said that the Akron factory and dock is large enough to manufacture a ship about twice the capacity of those now contemplated.

Shape of the Building—The airship docks at Karachi, at Lakehurst and at Scott Field have vertical ends and sides, the former closed by horizontally sliding doors. This shape is objectionable because it creates wind currents which interfere seriously with docking and launching operations. The design for the Akron airship dock was originated in the engineering department of the Goodyear-Zeppelin Corporation and final working drawings were developed by Wilbur Watson & Associates, Cleveland, Ohio, under the direction of Dr. Karl Arnstein, vice-president in charge of engineering of the Goodyear-Zeppelin Corporation. It will consist of a parabolic shell curving from a point about 30 ft. above the ground. Perhaps the most novel feature of the design is presented by the doors, which are composed of segments of a sphere supported at the top by a huge pin and at the bottom by trucks running upon a circular railroad track. Similarly shaped hangars and doors have been built in Germany, but in much smaller sizes. The doors at Akron will be operated by a fixed gear train engaging a movable rack attached to the lower part of the door.

Arch Design—The arches supporting the main shell are spaced 80 ft. apart on centers and carry a bracing system composed of horizontal and vertical trusses, which in turn support rafters spaced on 1 ft. centers, and these rafters carry the sub-purlins spaced on 8 ft. centers, to which the roofing plates are attached. The steel arches are designed as three-hinged for dead load only and are then converted at the completion of erection into two-hinged arches to resist deflection from wind. Wind stress determination on the structure was predicated upon wind tunnel tests made on a small-scale model at the New York University Daniel Guggenheim School of Aeronautics in New York City.

Layout—Since this dock will be primarily a manufacturing building, along each side of the shell will be extensive shops, storage rooms, offices, drafting rooms, etc., comprising the manufacturing facilities of the plant. The building will be equipped with elevators to carry workmen up and down, with overhead trolleys for assembly and with stairways and cat walks covering its entire inside periphery. Artificial lighting will be used for practically all assembly operations.

Submarine Gravity Tests Yield Valuable Results

On completion of his scientific voyage aboard the U. S. submarine "S-21," Dr. F. A. Vening-Meinesz reports findings which add materially to knowledge of the properties of the earth's crust and the shape of the earth. Cruising along the Atlantic and Gulf coasts and in Caribbean waters, Dr. Meinesz measured the acceleration due to gravity at many points both over "deeps" and near the continental shelf by means of his pendulum instrument. It had hitherto been impossible to attain these results, since observations from a surface vessel are not sufficiently accurate. A submarine, however, can go down into relatively quiet water where g can be measured within an error as small as 1 : 300,000.

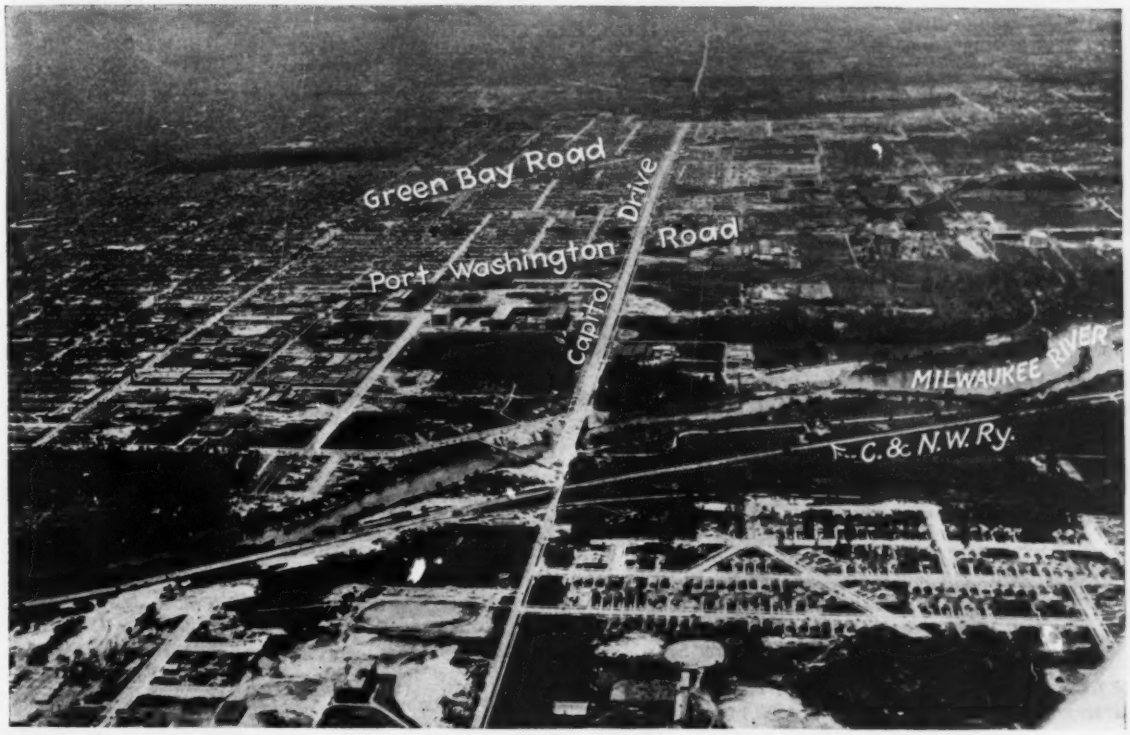
Preliminary computations indicate that the continent is not drifting slowly westward, as was supposed, which leaves students of isostasy to invent a new theory explaining the positive gravitational phenomena found on both the Atlantic and the Pacific continental shelves. Measurements near the Mississippi delta show that this mass of material is a "compensated feature on the earth's crust" having accumulated so gradually that equilibrium has been maintained without the development of an earthquake menace. The measurements in general, Dr. Meinesz declares, will be invaluable in establishing what might be termed the sea level shape of the globe. The estimated irregularity of 500 ft. in diameter could not be determined by any other known means.

New Facts on Salt Drainage From Irrigated Land

Extensive tests of soil water and water in the irrigation supply and in drainage from irrigated land, carried out recently on the Yakima reclamation project in Washington, are reported by C. C. Wright, of the Department of Agriculture, in Bulletin 228 of the State College of Washington (Pullman, Wash.). One of the main facts deduced from the analysis is that the drainage and underground water from normal productive land is just as salty as that from alkali areas. This fact, it is considered, indicates that at least part of the drainage and underground water, especially in alkali areas, comes from other sources than circulation through the upper soil layers. This conclusion was formed largely from studies on the Sunnyside division but was supported by observations on the Wapato division. In this region even land sufficiently alkaline to carry only thin and scattered salt grass vegetation showed little more salt in the underground water than in fresh irrigation water. The upper layers of soil are quite impervious. On the Sunnyside division, where the soil is more porous, water from wells was found to contain 400 to 1,200 p.p.m. of total salts, which is two to three times as much as the well water content on the Wapato division.

Engineering Problems of the Milwaukee Region

Official County Organization Covers Essential Metropolitan Area—Legal Authority From State—Effective Results in Highway Widening, Platting and Zoning



MILWAUKEE, A SUBURB AND THE COUNTY

Shorewood in foreground on near side of the Milwaukee River, Milwaukee to south (left) of Capitol Drive and county to north. Note the absence of through streets, the multiplicity of dead ends and the irregular platting, showing need of early guidance.

COMPARING THE WORK of the Milwaukee County Regional Planning Department with that of most other regional planning organizations shows that the principal difference is in the fact that it is a legally constituted agency. With a sympathetic overhead governing body, such as the Milwaukee County Board of Supervisors, forward-looking plans can be developed, their financing arranged and construction carried out. Many short cuts from conception to accomplishment are thus possible. The business of selling a large number of individual officials an idea and of activating them to put through their share of a general improvement is much simplified in the Milwaukee region. Because of the above-noted advantages, particular attention has been paid to the legal setup, method of operation and growth during its five-year period of existence. —EDITOR.

ORGANIZED regional engineering and planning for the metropolitan area surrounding Milwaukee, Wis., came to a head in 1923. In that year the Milwaukee County Park Commission called the attention of the County Board of Supervisors to confusion in the development of areas intervening between the cities of the county incident to the rapid growth in population and commercial interest. Better platting, zoning and parkway development were part of the suggested relief and a regional planning department as a part of the highway commissioner's office, with a $25,000 appropriation for 1924, was the agency set up.

Regional engineering had already been carried out in the county for specific purposes. The Metropolitan Sewerage Commission was in existence and the Milwaukee Park Commission was functioning. The County Regional Planning Department as such, however, was one of the first officially constituted regional bodies to function in this country, the Los Angeles County organization being established at about the same time. Functioning began April 1, 1924, with a planning engineer in charge and a staff of nine engineers. The positions were placed under civil service and had the benefit of state legislation enacted in 1919, authorizing counties to appoint a rural planning board in each county of the state. The law stipulated that in counties where there existed a county park commission it should function as a rural planning board.

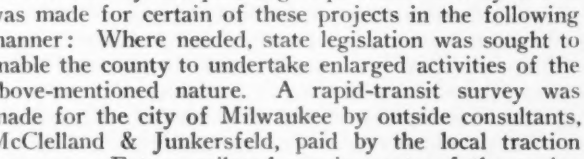
Under this arrangement the planning department served two purposes: first, to function as an engineering organization in the preparation and execution of county plans, and second, as an engineering organization to take care of general county engineering work. Three major activities first claimed the attention of the department: development of a proposed county parkway system, regional platting, and zoning. To these duties have been added general park engineering, preparation and supervision of planting plans for county parks, plans for a system of major highway widths, a study of flood con-

SETBACK OF A GARAGE AT AN INTERSECTION LOOKING FORWARD TO FUTURE WIDENED ROAD

ditions and their control and the checking of plats submitted to the county board for approval. At the end of 1924 special problems noted ahead of the department needing consideration in the development of metropolitan Milwaukee were rapid transit, railroad requirements, cross-diagonal highways, street grades on major highways within 3 miles of corporate limits of cities and villages, legislation for means to furnish a water supply to outlying districts and development of sewer systems connecting with the metropolitan system.

At the end of 1926 it was stated that definitely prepared plans were molding the district into an improvement over that of the past and that Milwaukee County was showing a steady growth without booms or depressions. Likewise the planning was not taken up spasmodically but was carried on continuously as the metropolitan district continued to grow. As in the previous year, the more important needs at that time were better co-ordination of municipal and county plans, better control of platting with respect to metes-and-bounds sales of land, co-ordination of platting and local business center development with future rapid transit lines, a complete survey of future recreational needs and an adequate water supply for the outlying districts.

Provision by the planning department and by others was made for certain of these projects in the following manner: Where needed, state legislation was sought to enable the county to undertake enlarged activities of the above-mentioned nature. A rapid-transit survey was made for the city of Milwaukee by outside consultants, McClelland & Junkersfeld, paid by the local traction company. Future railroad requirements of the region were being studied by the Harbor Commission in connection with a contemplated harbor terminal railroad. A plan for cross-diagonal highways was developed and several portions of it were laid out. Various towns developed local sewerage systems connecting with the metropolitan system. At this time the water-supply problem remained unsolved. However, as noted in the *Engineering News-Record* of Aug. 23, 1928, p. 273, the city water department did study the situation in a comprehensive way and planned a continuation of annexations to the city as a solution. At the present time the city of Milwaukee sells water to a number of the suburbs. Although the proposed annexations by the city in the unincorporated sections of the county is not strenuously opposed, it is generally felt by the suburban municipalities that a metropolitan water supply will some day be required, financed and governed as is the Milwaukee Metropolitan Sewerage Commission.



HIGHWAY-WIDENING SETBACK IN THE COUNTRY

During 1927 and 1928 the four major activities were: widening of trunk line highways, control of platting, county zoning, and development of a county parkway system. Much general engineering work was also done. Although cognizant of the necessity of rapid transit, water supply, sewerage and other regional community utilities, the department has let these special problems be handled, in so far as they are handled at all, by agencies created for specific purposes.

SIGNS APPRISE PEOPLE THAT ZONING ORDINANCE IS OPERATING

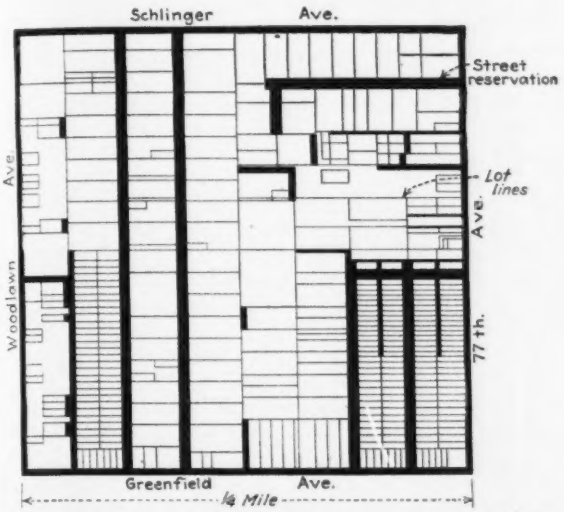
Following this rather hasty review of the development of this legally constituted regional agency and its scope of endeavor for the five-year period of its existence, the remainder of this article will be devoted to certain details as to the legal authority that has made it possible to develop to this stage, how the work has been financed, personnel and some further notes on the four major projects now claiming the department's activity.

NOTICE OF ESTABLISHED WIDTH IS POSTED ON EXISTING NARROW ROADS SELECTED FOR WIDENING

Legislation — Authority for any public work can be done legally only by grant of power from the state legislature. Wisconsin is one of the forward-looking states in granting powers affecting county planning. First is a general home-rule law granting counties of 250,000 population or more all powers of a local, legislative and administrative character, including control of water, sewers, streets and highways, fire, police and health. For these puropses districts may be created.

Next is rural planning, which is defined as necessary planning for the health, general welfare and amenity of the settler; planning for the establishment of the best possible transportation facilities; planning for the creation and development of the most logical community centers where people may come together for social and business relations; planning for the setting aside of country parks, recreation fields, county fair grounds, community woodland, places of local and historical interest and for the reservation of land for public uses along riverfronts, lake shores, fine outlooks from hilltops and for the preservation of the natural landscape. A

commissioner in the State Department of Agriculture presides over a division of rural planning to stimulate interest, to co-operate with county organizations and with the director of immigration in planning land settlement and colonization projects. Thus the region expands into state planning. By this home-rule law the county obtained rights to acquire, develop and maintain land for public use. The activities of the Department of Agriculture have been applied more specifically to the northern part of the state. In connection with rural planning and conservation the most important things have been done by the State Board of Health and the Railroad Commission in eliminating stream pollution.



RESULTS OF PLATTING PROPERTY AND ITS SALE BY THE METES-AND-BOUNDS METHOD

With no regard for adjoining streets neither uniformity nor continuity can be obtained.

Similarly, park commissions in the county were provided for. Besides acquiring by purchase, the commissioners may accept donations and subsequently dispose of lands; thus the right of eminent domain is given—a sort of excess condemnation. Airport acreage may be acquired and provided with equipment. For county park purposes up to 1927 a one-tenth mill tax was automatically provided. At the 1927 session of the legislature the mandatory provision of this statute was amended to make it optional with the county board. Since that time the county has granted the park commission funds far in excess of the one-tenth mill tax originally allotted to it. Special assessments may be made for park improvement purposes, but no special assessments may be made except within 1½ miles of the limits of incorporated cities and villages, and based on these assessments bonds may be issued as liens on the property.

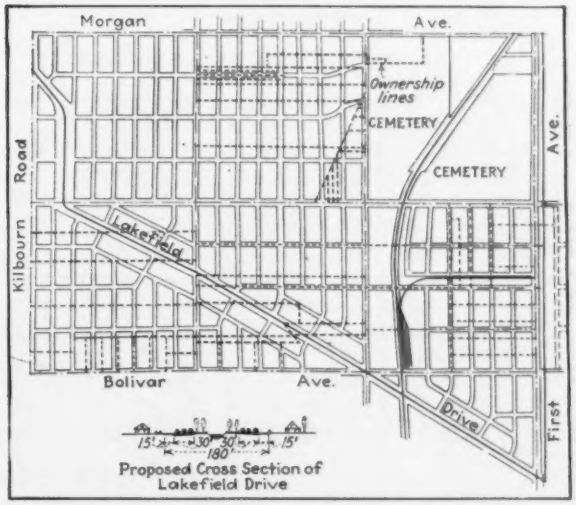
The power of zoning for use only is established by legislative action, as is the power to widen trunk highways.

Certain platting laws govern in the whole state, but there are special laws for Milwaukee County. Essential regulations for Milwaukee and 1½ miles beyond the city limits are given in a platting guide prepared by city officials. Similar rules are set up by the Regional Planning Department, and the owner, by law, must plat to the satisfaction of the county board and town boards, otherwise the plat cannot be recorded and sale cannot be made without a penalty of not less than $100 or more than $1,000. Regional plans for platting may be made in such units as the county park commission may determine, but before adoption hearings must be held. This gives a chance to establish through routes and extensions of existing streets. Such regional plans are defined as a system of arterial thoroughfares complete for each town, a system of minor streets for the complete area surrounded by any such main arterial thoroughfares and connecting therewith and the platting of lots for any area surrounded completely by any arterial thoroughfares or any such minor streets or both. Natural obstacles such as a lake, a river or a railroad may be considered a boundary.

Finances and Personnel—Up to 1928 the county board appropriated $25,000 each year for the maintenance of the regional planning department. For 1928 the sum of $27,500 was available and the 1929 budget calls for $37,970, divided as follows: Personal service, $32,620; office and automobile supplies, $1,875; materials, $100; transportation, printing, etc., $2,515; vehicle license, insurance fees, $180; equipment furniture and scientific instruments, $280; convention fund, $400.

The original staff of nine has grown to double that number. The planning engineer is also the highway commissioner and not charged to this account. His staff is made up of a supervising engineer, a senior assistant engineer, an assistant engineer, a landscape engineer, two junior assistant engineers, eight junior engineers, three rodmen and a stenographer.

Highway Widening—In Milwaukee County the general county funds for highway purposes are spent on the

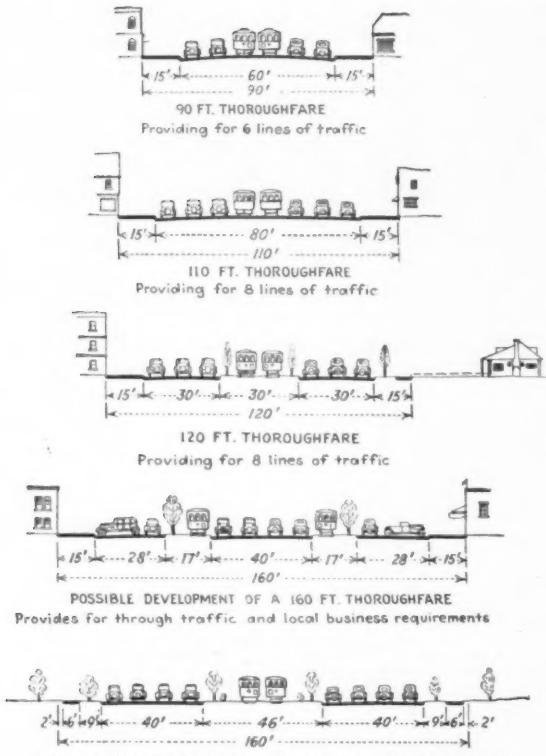


PLATTING ADJACENT TO A PROPOSED DRIVEWAY TO CARRY RIVER IN ITS CENTER

Streets crossing driveway are maximum distance apart and at right angles for added safety. To effect such a platting ownership must be reassembled.

state and county trunk system outside of the limits of incorporated cities and villages, although on state trunk highways construction is sometimes carried within incorporated cities or villages to the point where houses fronting on the highway average not less than 200 ft. apart. Right-of-way for highway widening must be financed by the county, and for some time a county trunk system has been laid out according to which the county is building. The system is continually being added to and perfected.

The problem of the county is how to handle the traffic within a ring around the metropolitan area; first, to provide highways adequate to handle the traffic moving to, from and about the metropolitan area, and second, to provide highways in such design that when the built-up


15' 60' 15'
90'
90 FT. THOROUGHFARE
Providing for 6 lines of traffic
15' 80' 15'
110'
110 FT. THOROUGHFARE
Providing for 8 lines of traffic
15' 30' 30' 30' 15'
120'
120 FT. THOROUGHFARE
Providing for 8 lines of traffic
15' 28' 17' 40' 17' 28' 15'
160'
POSSIBLE DEVELOPMENT OF A 160 FT. THOROUGHFARE
Provides for through traffic and local business requirements
2' 6' 9' 40' 46' 40' 9' 6' 2'
160'
ANOTHER POSSIBLE DEVELOPMENT OF A 160 FT. THOROUGHFARE
Through a residential district

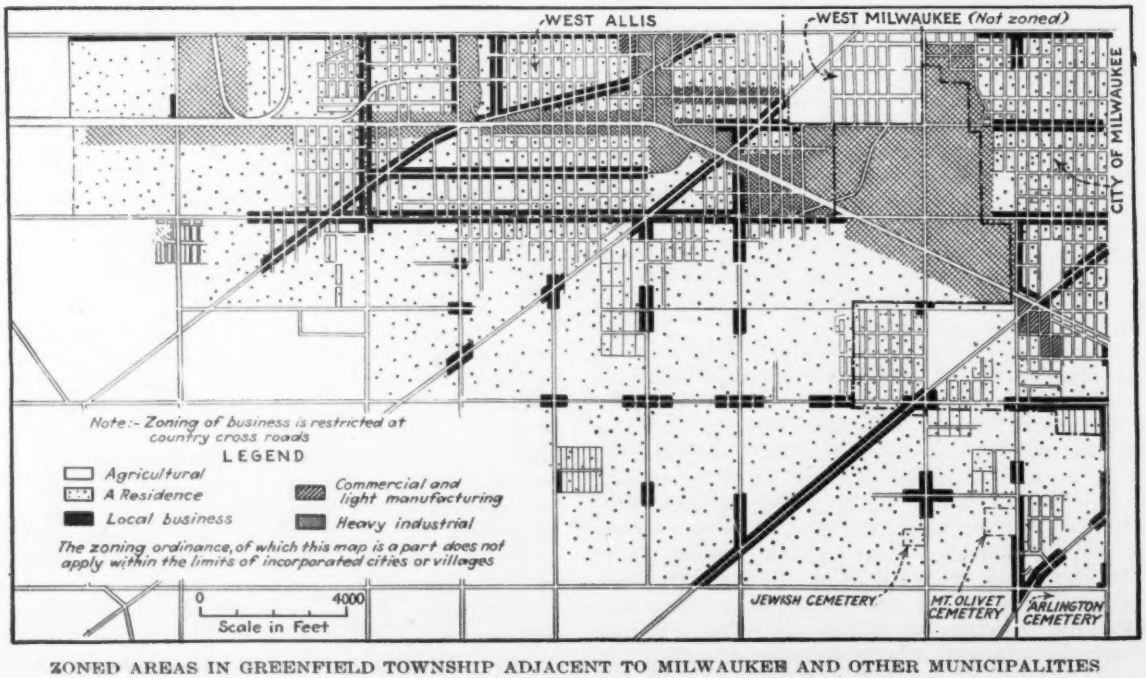
HOW HIGHWAY WIDTHS ARE ALLOCATED

area expands, the major arteries of the county will then function as adequate major arteries of the city. To care for the present traffic and that expected in the near future, the paved portion of the trunks needed widening. Most of the rights-of-way were the usual four rods between property lines, and as a consequence only limited pavement widening was possible. Therefore, to satisfy both the first and the second requirements noted above a procedure to acquire a wider right-of-way had to be developed. It was the job of the regional planning department to determine not only on the system but on widths and methods of acquisition. The system was determined by traffic census, prospective use of the land, segregation of types of traffic, industrial needs and relation to the county parkway system. Particularly did the engineers keep in mind that the system must be flexible and not dependent on a few main highways.

Widths as determined in the Chicago, Detroit and other metropolitan regions were studied, with the conclusion that most authorities agreed that the more important highways should be at least 100 ft. wide and that 110 or 120 ft. is preferable.

To acquire 120 ft. of right-of-way all at once on any given highway is not only prohibitive in cost but an unnecessary withdrawal of land from private occupancy if it is not to be used for a number of years. Three methods of acquisition have been used in Milwaukee County. The first is the ordinary procedure of dedication when the land is being platted for sale as lots. In general in regular section-line platting 110 to 120 ft. is required on section lines and 90 ft. on half-section lines. This is controlled by the necessity of plats being approved by the county board, which without exception refers all plats to and accepts the recommendations of the regional planning department.

The second method is a setback control applied to unplatted lands, or lands which had been platted to a narrower width previous to the origin of the county planning department. When the owner wishes to build, he is required to obtain a building permit, which is not granted unless the setback is observed. Although this does not obtain the land required, it materially reduces future costs. On roads to be widened signs are posted giving notice of newly established widths. The third procedure is also a method of dedication. In unplatted lands the land is dedicated and the county pays for actual damages to physical property, such as the cost of removing buildings, wells, fences and improvements of a like nature. In platted property it is often necessary to pur-


WEST ALLIS
WEST MILWAUKEE (Not zoned)
CITY OF MILWAUKEE
Note:- Zoning of business is restricted at country cross roads
LEGEND
Agricultural
A Residence
Local business
Commercial and light manufacturing
Heavy industrial
The zoning ordinance, of which this map is a part does not apply within the limits of incorporated cities or villages
0 4000
Scale in Feet
JEWISH CEMETERY
MT. OLIVET CEMETERY
ARLINGTON CEMETERY

ZONED AREAS IN GREENFIELD TOWNSHIP ADJACENT TO MILWAUKEE AND OTHER MUNICIPALITIES

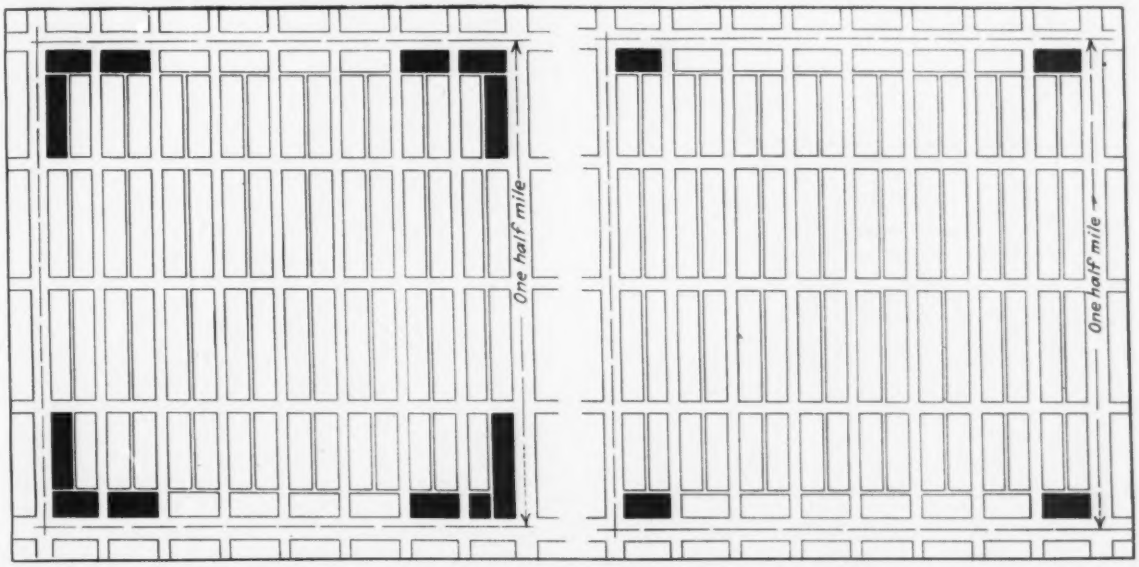
chase, outright, lots lying parallel to the improvement, or, where lots face the highway, to purchase one or two lots in the rear of those facing the highway and then rearrange the platting by shoving back those lots abutting on the highway to be widened. The principal costs under this system have been for physical improvements.

As a tangible result of the efficacy of the regional planning department in acquiring rights-of-way it may be noted that some 50 miles of wide right-of-way have been obtained by plat dedications. This last year it was desired to complete at once the widening to 120 ft. of Capitol Drive for about 20,000 ft. One-fifth only had been obtained by dedication; the remaining 16,250 ft. cost $60,000. Likewise on widening Blue Mound Road to 120 ft. a total of 19,300 ft. was needed, whereas only 5,860 ft. had been obtained. The remainder cost $75,000. Estimating the value of the 50 miles that has been acquired through the activities of the regional planning department at $25,000 per mile (rough average of above costs), it is seen that this procedure has brought to the county $1,250,000 worth of right-of-way for future roads without other cost than the maintenance of the platting division of the department.

In the article on the Chicago region in *Engineering News-Record* of Nov. 22, 1928, p. 758, mention was made of the Three-State, 200-ft. Boulevard project, with Milwaukee as the northern terminus. Milwaukee County feels that 160 ft. is sufficient width in the Milwaukee region, since there will be many feeders and distributors from this terminus as well as bypassing around the city. Appraisers are now at work acquiring a 160-ft. width on this road for a distance of 4½ miles immediately south of the city limits.

Platting—As no plats can be recorded unless "prepared to the satisfaction of the county board," wide leeway is given the regional planning department. This ruling applies to the towns (subdivisions of the county usually called elsewhere townships) which have to approve the plats. The town and municipal boards work in harmony with the regional planning department. The city of Milwaukee and the county jointly control platting within a strip 1½ miles outside of the city limits. The procedure has been for the regional planning department to work out a general pattern, letting the subdivider fit in the detail, subject to the department's regulations. Since much of the county is fairly rugged, topography has been taken over two-thirds of the area. In accordance with this topography and the general highway system an aggregate of 54 square miles of the 180 square miles outside of municipalities has been worked up into master plats to be used as guides for future platting.

Much property in the county has been and still is being laid out and sold by metes and bounds. This method has become a nuisance, because it does not fit into the master platting plan. Moreover, the tax assessors miss much property because of lack of proper descriptions. The department has been mapping all of the metes-and-bounds property. The next legislature will be asked for some kind of relief that will prevent obvious attempts at evasions by metes and bounds of the regular subdivision responsibilities.



BUSINESS FRONTAGE IN ACTUAL USE IN EXTREMES OF RESIDENTIAL AREAS OF MILWAUKEE APPLIED TO CORNERS OF QUARTER SECTION

Zoning—Milwaukee County is one of the first counties of the country to have a zoning ordinance for areas outside of incorporated municipalities. It covers use only, not height or density. The regular divisions of heavy industrial, commercial and light manufacturing, local business, and residence zones are supplemented by an agricultural zone outside of the built-up areas around the municipalities. To be effective, towns (townships) had to vote approval of the ordinance, which is dated Oct. 25, 1927. Five of the seven towns of the county have done so. They are adjacent to the city of Milwaukee. Hearings followed surveys to determine existing conditions of use, and now the statute is operative in the five towns.

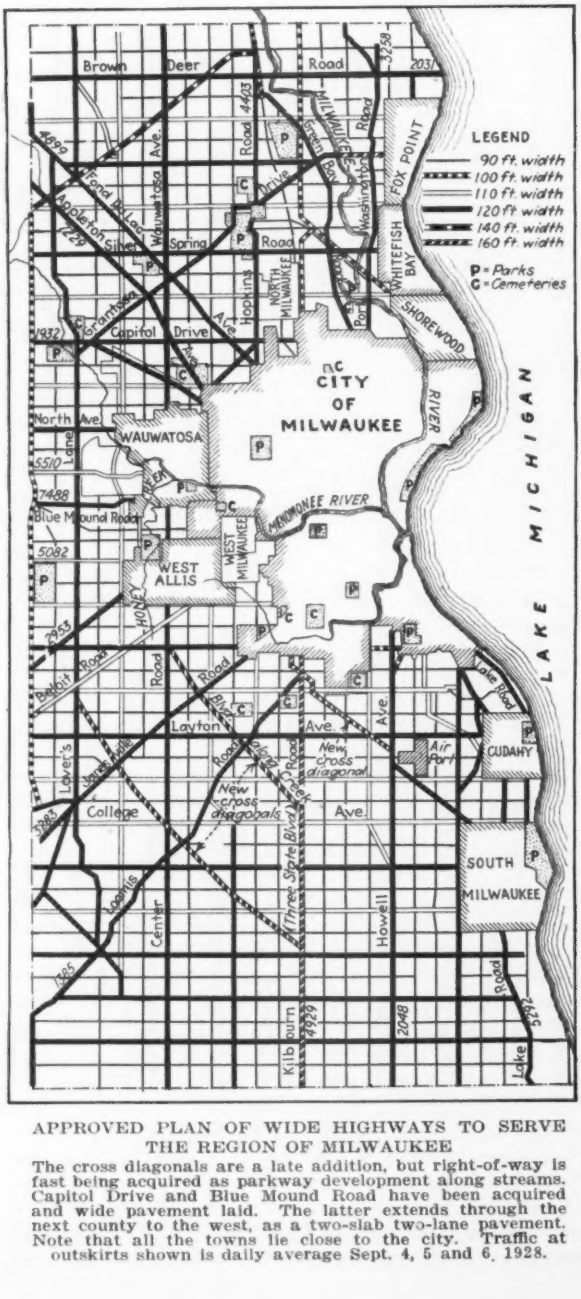
To make the zoning ordinance workable, a county building ordinance was passed carrying a provision for a building inspector. In addition to inspection as to compliance with the zoning ordinance, this inspector requires location details as well as proposed use of structure before issuing a permit, a procedure that gives the county control over the observance of the setback provisions.

Before proceeding to lay out the "use districts" the following subjects were thoroughly investigated: Location and present use of every building; location of railroads and facilities; location of areas well defined for business or industry by reason of occupancy; existing

zoned districts inside the municipalities; main highways, streets and interurban lines; topography; population trend; relation to parks and other public or semi-public lands or institutions.

The agricultural district was created with the idea that changes in the zones would develop with the land, with revisions as needed.

To determine an engineering basis for the relation of local business to population and area, a survey of six typical areas in and around Milwaukee was made. As in the Chicago region, an average of 52 ft. per 100 persons was found to be the local business frontage actually used, though the variation was from 31 ft. in the best residence district to 73 ft. in the industrial city of West Allis. The percentage of the total area in actual business use averaged 4 per cent, ranging from 0.77 per cent in Wauwatosa to 6.22 per cent on the south side of Milwaukee. The percentage of frontage zoned as business in actual use averaged 40 per cent, but varied from 19 per cent in Wauwatosa to 68 per cent in the northeast side of Milwaukee. The business frontage actually in use in the extremes noted above, when applied to the four corners of a quarter-section, indicate graphically the futility of zoning the frontage on every street to business. If all of this frontage were developed, it could not be supported, and only enough frontage to give a reasonable "factor of competition," as apparently had been zoned within the built-up areas, has been allowed in the county areas.



APPROVED PLAN OF WIDE HIGHWAYS TO SERVE THE REGION OF MILWAUKEE

The cross diagonals are a late addition, but right-of-way is fast being acquired as parkway development along streams. Capitol Drive and Blue Mound Road have been acquired and wide pavement laid. The latter extends through the next county to the west, as a two-slab two-lane pavement. Note that all the towns lie close to the city. Traffic at outskirts shown is daily average Sept. 4, 5 and 6, 1928.

County Parkway—A parkway system in general following watercourses has been laid out and several stretches have been obtained as to right-of-way. Construction of the first mile of pavement will be built this year, although considerable grading work has been done heretofore. About 100 acres of land has been acquired by dedication. Several additional sections are under consideration. Improvements such as grading, drainage and pavement are paid one-half by special assessment and one-half by the county. The latter will pay out of the general fund such cost of park development as landscaping, planting and maintenance. The park development is not entered into without petition of property holders and dedication of the land.

Water Supplies—Milwaukee furnishes chlorinated but unfiltered water from Lake Michigan to West Allis, West Milwaukee, North Milwaukee, Shorewood and Whitefish Bay. Wauwatosa has a series of wells and elevated tanks. Cudahy gets lake water from the Cudahy Packing Company. South Milwaukee filters its own lake supply. The remainder of the regional communities use wells, the water from which is relatively hard. There is some agitation for a metropolitan water district that would utilize Milwaukee as the nucleus and take in contiguous built-up area just as has the Metropolitan Sewerage Commission.

County Airport—In October, 1926, Milwaukee County purchased for an airport site something over 400 acres of land in the town of Lake, 7 miles south of the Milwaukee post office, with which it is connected by good roads, so that the airport is only twenty minutes away by automobile. The grading, drainage and improvement with hangars and service building, lighting and permanent runways were carried out with county funds.

Summing up, there is noted here an official regional planning organization that is in effect operating as a kind of department of public works for the county board. Its activities do not cover all phases of the regional engineering or physical needs, but it has made a distinct place for itself and has obtained legislative sanction to certain essential factors that go far toward permitting and guiding the outlying portion of the Milwaukee metropolitan area to a growth in an orderly fashion. Platting of land and its use by zoning is well controlled. By means of control, transportation, now and in the future, is being well cared for. Recreational facilities are being closely co-ordinated with flood control, transportation and adjacent land platting.

F. F. Cavanaugh, highway commissioner and planning engineer, heads the regional planning department. E. A. Howard is the supervising engineer, Ray E. Behrens senior assistant engineer, and A. L. Boerner landscape architect. C. B. Whitnall, formerly secretary of the County Park Commission, was actively responsible for the initiation of the department, which is co-ordinated with the Park Commission under a sympathetic and far-seeing County Board of Supervisors.

Long Belts Transport Aggregates and Concrete for Hudson River Bridge Anchorage

106,000-Cu.-Yd. Concrete Block 155 Ft. High Will Hold New York End of 36-In. Suspension Cables—Materials Moved 1,000 Ft. by Belt Conveyor System—Final Distribution of Concrete by Chutes From 260-Ft. Tower

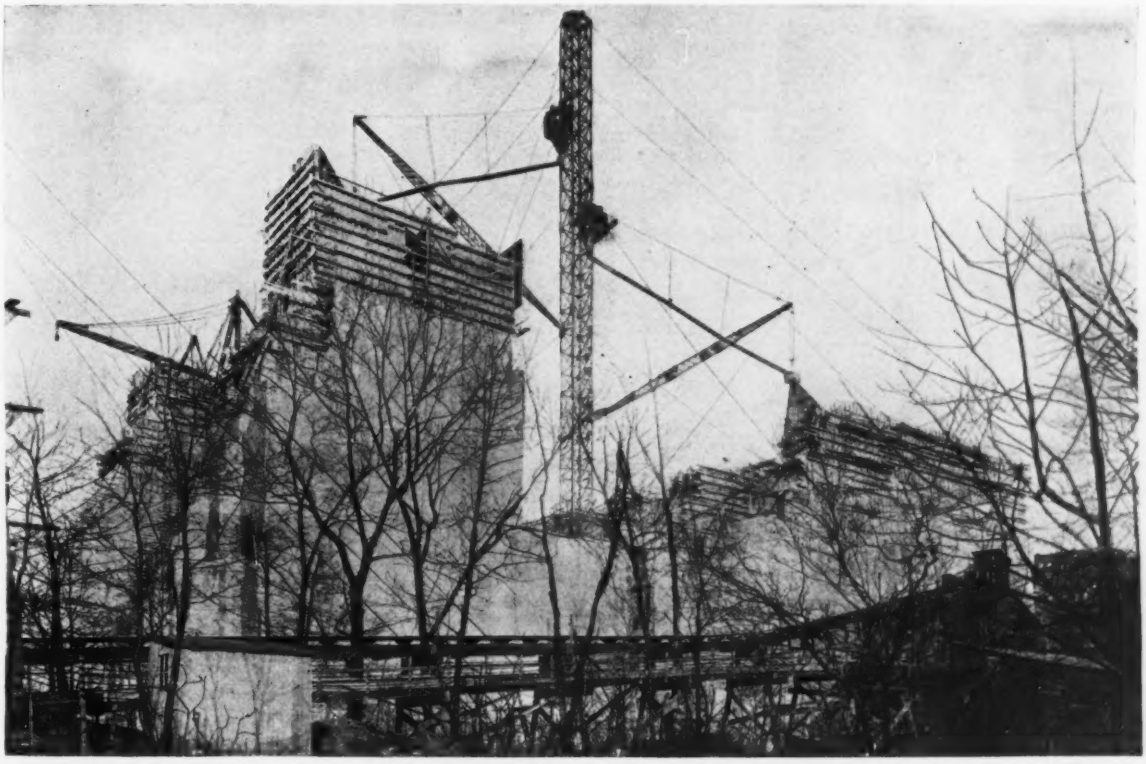


FIG. 1—CONCRETE PLANT AND 106,000-CU.YD. ANCHORAGE FOR NEW YORK END OF HUDSON RIVER SUSPENSION BRIDGE

IN CONTRAST to the New Jersey anchorage, buried deep in two sloping tunnels in the Palisades (described in *Engineering News-Record*, Oct. 25, 1928, p. 610), the New York anchorage of the Hudson River suspension bridge rises as a huge block of concrete 155 ft. high and roughly 282x176 ft. in plan. Approximately 106,000 cu.yd. of concrete and 2,200 tons of eyebars and steel grillage comprise the mass that will hold the eastern end of the four 36-in. cables carrying the 3,500-ft. span of the bridge.

Running as high as 1,200 cu.yd. in a sixteen-hour day, a modern electrically operated twin-mixer plant has poured the entire yardage in 5½ months, or 2½ months ahead of schedule, as is shown in Fig. 7, and 3½ months ahead of contract limit. Dry aggregates were transported a thousand feet by belts to the mixer, part of the way up a 32 per cent grade. A high-speed belt carried the mixed concrete from the plant to a 260-ft. tower in the center of the anchorage, where boom and counterweight chutes made the final distribution.

Design of Anchorage—The relative locations of the New York anchorage and tower can be seen from Fig. 5, which also shows the concrete plant layout. The anchorage itself (Fig. 2) consists of a U-shaped concrete block, covering an area 282x176 ft., resting on an uneven solid rock foundation, with the open end of the U pointing west toward the river and the New York tower, 650 ft. distant. As solid rock outcrops at the site, very little excavating other than light stripping was required. The two legs of the anchorage rise at the west end as buttresses to carry the splay castings of the cables and the stiffening truss anchors. At this point the cables coming from the towers spread out into strands to grip the eyebars of the steel grillage. This steel, in two sets, totaling 2,200 tons, is buried in the east end of the block, as is shown in Fig. 11. A reinforcing mat consisting of ¾-in. round horizontal bars on 18-in. centers and ¾-in. vertical bars on 18-in. centers was placed near all of the outside faces of the anchorage. On horizontal surfaces and in parts of the structure under high stress, mats of 1-in. square rods on 12-in. centers were used.

Several tunnels provide for access through the anchorage, running transversely and longitudinally at different elevations, one at the rock level containing weep holes for drainage. During the construction operations temporary keyways or openings divided the structure into four parts to allow for even curing and shrinkage, the

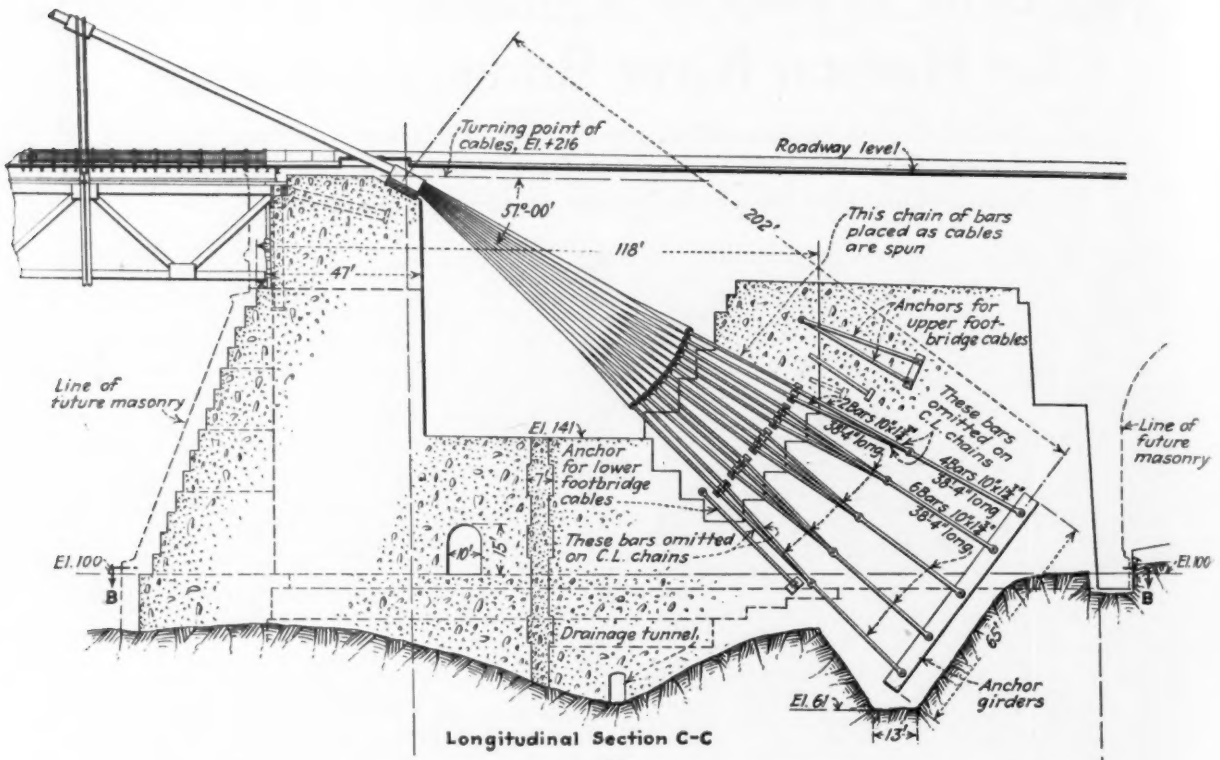


FIG. 2—PLANS AND SECTION OF NEW YORK ANCHORAGE, HUDSON RIVER BRIDGE
Upper portion of lower figure shows half-plan. In actual construction the narrow steps shown in the half-plan were changed to battered surfaces.

FIG. 3—VIEW OF ANCHORAGE WITH TOWERS IN BACKGROUND
Concrete plant and belt conveyor suspension bridge can be seen at lower left.

keyways being filled in at the close of the job. A granite block facing doweled to the concrete by 1-in. square bars will be placed over the entire exposed surface except the east side and the inside portion except for a short return at the west end.

Concrete for the anchorage was designed for a compressive strength of 2,000 lb. per sq.in. in 28 days, was proportioned by the water-cement ratio, and was mixed 1½ minutes. The approximate mix used was 1 : 2.21 : 3.70, varying with the aggregates, using 7 gal. of water per sack, giving a slump of approximately 4 in. Gravel was used as coarse aggregate for the most part except for a short period of gravel delivery failure, when crushed stone was used. A uniform strength in excess of the 2,000 lb. at 28 days specified was obtained by the use of slightly less than five bags of cement per cubic yard of concrete. The aggregate proportions were by weight on the basis of a bag of cement weighing 94 lb. The cement was not weighed.

Design of Steel Grillage—Two complete sets of anchorage steel are used, one for each pair of cables. Auxiliary anchorage steel is provided to hold the footbridge cables. Each set of the main cable anchorage steel consists of twenty 60-in. plate girders, sixteen of them 69 ft. long and four 46½ ft. long, standing on end in a single row sloped so as to be normal to the center line of cables. The eyebar system for each set of steelwork consists of 488 bars 10x1¾ in. in section in two 38 ft. 4 in. lengths between the cable ends and the anchorage girders. Pins 10 in. in diameter are used for all connections.

Construction Operations—A wide variety of possibilities in the layout of a concrete plant for the anchorage was apparent from the start. As can be seen from Fig. 5, the structure lies between Riverside Drive and the New York Central freight tracks, and the distance to the river is only 700 ft. Materials could be delivered directly to the site by trucks or to the near-by shore line by barges. Considering barge delivery, several methods of getting material to the actual site were available. Trucks, cableways and belt delivery were possible for transporting either dry materials or mixed concrete from the riverfront to the anchorage. Furthermore, final distribution of concrete offered a variety of methods.

The plant layout finally adopted and successfully used consisted essentially of delivery of dry materials to a riverfront dock by barge, transportation by belt system to the concrete plant at the anchorage, delivery of mixed concrete to the base of a chuting tower by belt, and final distribution of concrete by boom and counterweight chutes. Obviously, the smooth operation of such a plant depended on the proper synchronization of all functions.

Aggregate Belt Conveyor System—Sand and gravel were unloaded from barges by two steam-operated stiff-leg derricks and placed in separate piles over a 6x6-ft. wooden tunnel 300 ft. long parallel to the dock. An auxiliary stiff-leg derrick and a crawler crane equipped with a clamshell bucket were used to handle material to storage piles adjacent to the tunnel. In the roof of the tunnel under each of the two stockpiles were several hopper gates which opened directly upon a belt conveyor running lengthwise through the tunnel. A storage of 2,400 cu.yd. over the tunnel of both sand and gravel was necessary for the proper operation of the belt loading system. An endeavor was made to keep at least 3,000 cu.yd. on hand in the auxiliary piles to protect the plant. Sand and gravel are alternately dumped upon this belt as needed, being carried to the mixing plant by another belt system running approximately at right angles to the river. The tunnel belt was 26 in. wide, traveled at a speed of 375 ft. per minute, had a capacity of 300 tons

FIG. 4—BELT CONVEYORS ON 32 PER CENT GRADE
Concrete distribution tower in background. Picture was taken at start of job, so none of anchorage structure is shown.

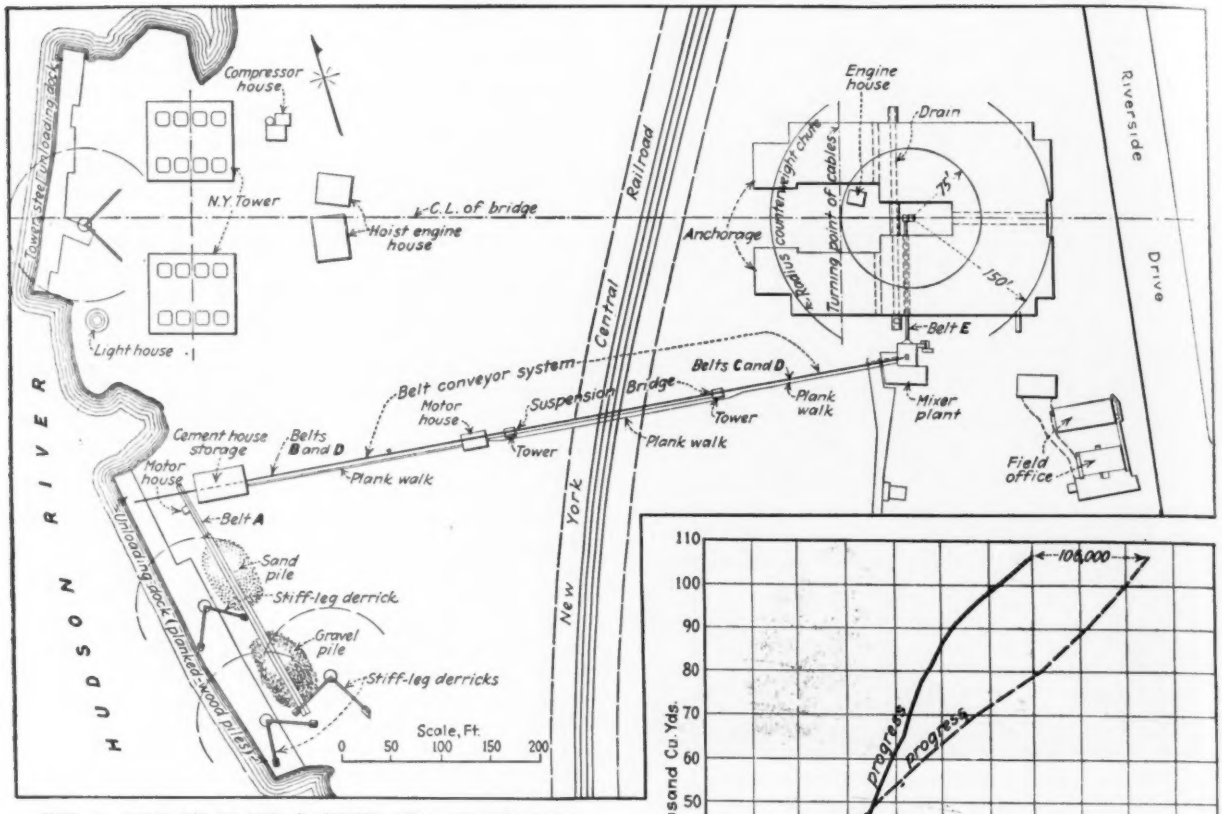


FIG. 5—MAP OF PLANT LAYOUT AND ANCHORAGE, NEW YORK END OF HUDSON RIVER BRIDGE
Relation of anchorage to New York tower is shown.

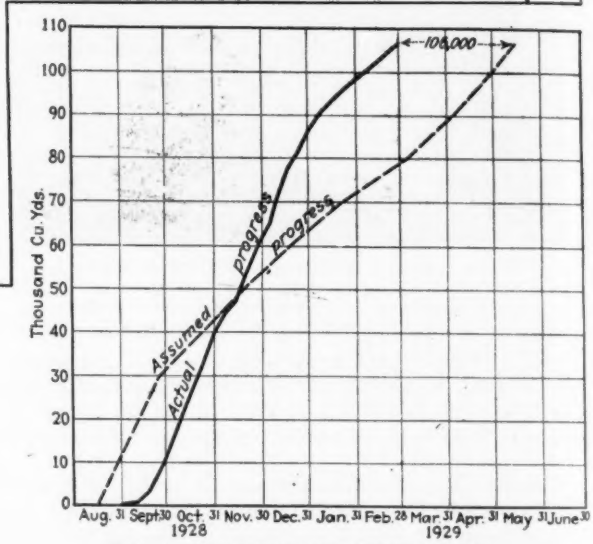


FIG. 7—CONCRETE PROGRESS CHART
Assumed progress based on early estimates of engineers.

per hour and was driven by a 15-hp. electric motor. The belt through the tunnel discharged directly upon the conveying system leading to the concrete plant. This system consisted of a sand and gravel belt 375 ft. long and 26 in. wide connected in tandem to a similar belt 390 ft. long discharging into the material hoppers at the plant. The arrangement of these belts can be seen from Figs. 5 and 6. Breaking the aggregate belt was the

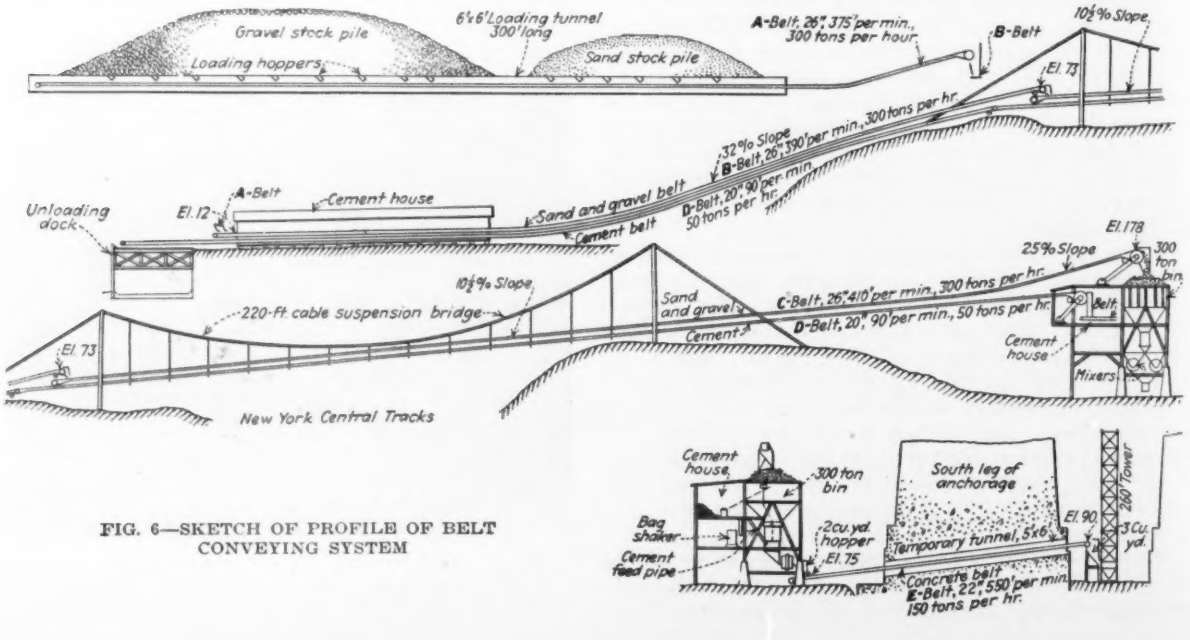


FIG. 6—SKETCH OF PROFILE OF BELT CONVEYING SYSTEM

economic choice of the cost of an extra motor and tail pulley against the cost of an extra-heavy single belt necessary to withstand the tension resulting from such a long belt fully loaded. The first of these two belts traveled at a speed of 396 ft. per minute, with a capacity of 300 tons per hour, and rose up a 32 per cent slope over a small rocky hill. At the break between the first and second belts, the slope flattened out to 10½ per cent, cross-

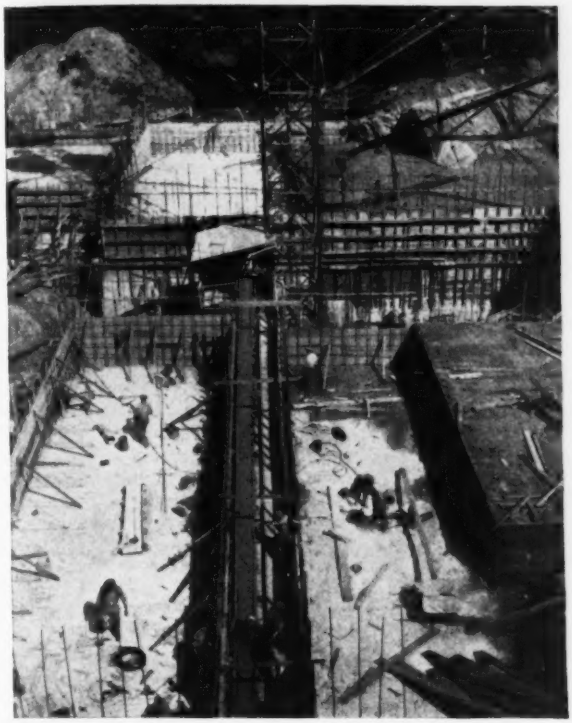


FIG. 8—LOOKING DOWN ON CONCRETE DELIVERY BELT FROM TOP OF MIXING PLANT
Picture shows construction of forms for temporary tunnel through south leg of anchorage which later inclosed belt.

ing the New York Central Railroad tracks on a 220-ft. span suspension bridge. The second of these two belts had a speed of 410 ft. per minute but with the same capacity of 300 tons per hour. This belt discharged directly into a 300-ton storage bin at the top of the mixing plant. Each belt was driven by a 40-hp. motor. One belt conveying system was used for both sand and gravel, the material being transported alternately, with the mixer storage bin acting as a regulating supply.

Cement-Handling Belt—Cement in bags was unloaded directly from barges to the dock by cranes on the barges. Running from the dock to the mixing plant was one continuous belt 780 ft. long, located directly under the second and third sand and gravel belt. The cement in bags was placed on this belt by hand and run through a storage house of 10,000-bag capacity built on the shore line next to the dock. This belt ran at a constant speed of 90 ft. per minute and the cement either was taken off as it passed through the storage house or went directly to the mixing plant, whichever might be required. The storage house was for emergency storage only, as most of the cement passed directly from the barge to the mixing plant. The cement belt was rated at 50 tons capacity per hour and was operated by a 20-hp. motor.

Mixing Plant—The mixing plant consisted of two 28-S electrically operated automatic-timed mixers charged by a single weighing batcher plant. Sand and gravel were

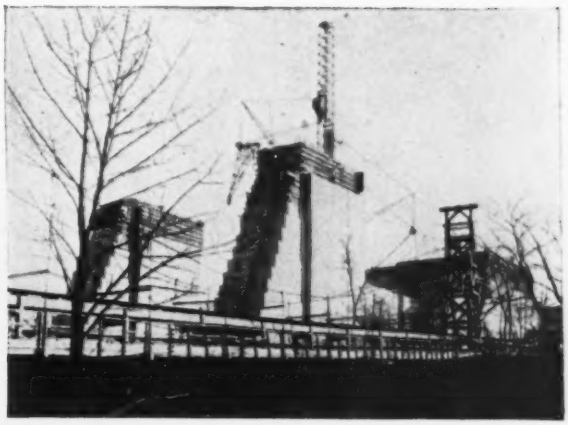


FIG. 9—SUSPENSION BRIDGE OF 220-FT. SPAN CARRYING BELT CONVEYORS OVER NEW YORK CENTRAL TRACKS

fed to the batcher from overhead steel storage bins with a capacity of 100 tons of sand and 200 tons of gravel. The cement coming from the long cement belt was dumped onto a chute leading to a short conveyor belt in the cement house section of the mixing plant. From this belt the cement was unloaded by hand, unsacked and dumped into two sheet-iron pipes leading to the mixer, six bags being used per batch. The normal operation was to have the cement delivered to the charging pipes at the rate of using to avoid rehandling. Only the excess due to short shutdowns was piled. A storage of 2,000 bags was maintained at the plant.

On account of the massiveness of the structure, no provisions were made for protecting the concrete against frost except by heating the water and aggregate. For this purpose a heating plant was built adjacent to the mixing plant containing a water heater for the mixing water and a steam boiler supplying steam to circulating

FIG. 10—ERECTING ANCHORAGE STEEL

FIG. 11—VIEW OF ANCHORAGE STEEL PARTLY EMBEDDED IN CONCRETE

pipes in the aggregate storage bins. At the stockpiles steam pipes were laid along the top of the tunnel, being supplied by the derrick boilers.

Concrete Distribution System—The two mixers dumped into a common receiving hopper, which in turn discharged to a belt conveyor 125 ft. long, operating through a temporary tunnel through the south wing of the anchorage (Fig. 8). This belt discharged into a receiving hopper at the base of a 260-ft. steel tower. The concrete belt operated at a speed of 550 ft. per minute, using a 7½-hp. motor. Two chuting systems, consisting of a 75-ft. boom chute and a 75-ft. counterweight chute hanging on the end of the boom chute were mounted on the east and west faces of the tower; 14-in. chutes were used to allow easy flowage of concrete and to prevent clogging as much as possible. The tower itself was firmly guyed, although the two separate chutes acted somewhat as a balance. The boom and chutes were fastened to the tower by a sliding frame arrangement operating on guide angles provided for the lowering or raising of the entire set of chutes. Concrete was hoisted to receiving hoppers at the top of the boom chute by a 36-cu.ft. roller hoist bucket dumping two ways. This bucket traveled at a speed of 380 ft. per minute and was operated by a hoist using a 100-hp. electric motor. The same hoist also handled the chute booms and the lifting frames of the chute systems.

The discharge end of the counterweight chute was steadied by the use of a 10-ft. T-post, which acted as a prop near the end of the chute. The concrete was placed in layers 4 ft. deep and the flexibility of the chuting system required but little rehandling by hand.

The concrete plant averaged 1,000 to 1,200 cu.yd. per day of two eight-hour shifts. Non-working days, delays in form setting, material delivery and the time necessary for the anchorage steel erection cut down the monthly average to approximately 20,000 cubic yards.

The contractors consider the design and operation of the plant satisfactory, with few suggestions for improvement if the plant were to be duplicated. No slippage of material, either aggregates or cement, was experienced on the steeply sloping section of the belt conveyors. While this installation proved satisfactory, the builders of this plant believe that a 32 per cent slope is about the limit for conveying dry aggregates. The second and third belts handling aggregates operated at an increased speed over the first and second belts, respectively, to avoid piling up of material should one of the motors slow down a trifle below rated speed. As a result of this precaution practically no material was spilled off the belts.

Anchorage Steel Erection—Steel falsework to hold the anchorage steel eyebars during erection was built for each set of anchorage steel and was embedded with the steel. The steel was delivered to the site by trucks and was erected by steel guy derricks. The entire anchorage steel, weighing 2,200 tons, was erected in four weeks' time.

Contractors and Personnel—The bridge is being built by the Port of New York Authority, O. H. Ammann, chief engineer of bridges, and Montgomery B. Case, engineer of construction. The New York anchorage is directly under the supervision of Robert Hoppen, Jr., resident engineer. The contract for the anchorage work was held by the Arthur McMullen Company, of New York. The plant was designed by E. P. Palmer, secretary, and H. B. Gates, engineer, of the McMullen Company. Thomas A. McGuire was superintendent and F. P. King was assistant superintendent for the contractors. The McClintic-Marshall Company, contractor on the steel erection of the bridge, was sub-contractor on the erection of the anchorage steel.

Failure of Dividing Wall in Old Coagulation Basin of Baltimore Water-Filtration Plant

Just Before Resuming Minor Repairs Water Burst Through Floor of Empty Basin and Swept Out Dividing Wall—Similar Floor Leak Twelve Years Ago Created Holes Beneath Wall Which Were Then Filled

By James W. Armstrong
Filtration Engineer, Baltimore, Md.

ON FRIDAY morning, March 22, Coagulating Basin No. 2 of the older of the two Baltimore water-filtration plants at Montebello, was emptied, Basin No. 1 being full at the time. About 11:30 a.m., without warning, eight 32-ft. sections of the dividing wall between Basins 1 and 2 gave way and were pushed horizontally outward in Basin No. 2, liberating some 8 m.g. of water. As this great volume of water rushed into the empty basin, the wall sections, many tons of earth and broken concrete, and floor slabs were hurled forward. One mass weighing several tons was carried half way across one half of the basin and stopped by the baffle wall, which was uninjured. That a section of wall 240 ft. long, weighing hundreds of tons, could have been moved, and that parts of it could have been carried over 60 ft., seems incredible to everyone who has witnessed the scene of the failure.

An Eyewitness—A. A. Bailey, who has charge of the mechanical work at Montebello, was the only eyewitness of the failure. I am quoting from a report written by him describing the accident:

> At about 11:15 a.m. I was looking down into Coagulating Basin No. 2. There was no sign of water coming through any of the joints in the floor slab. About ten minutes later I returned to the basin and noticed a few small streaks of light color in the mud, which appeared to be moving in the direction of the center gutter. The floor was covered with about an inch of mud at that time. I then stepped closer to the window to see what caused these streaks and by that time small streams of water were starting to spout up through the joint between the wall footing and the first floor slab for a distance of between 10 and 15 ft. opposite the sixth section west of the building. I immediately ran to the drain gate, about 15 ft. away, but by the time I had reached it the water was raising the floor slabs and beginning to pour through at a terrific rate. As soon as the floor slabs broke, the wall started to move, opening first at the joint between sections 5 and 6, just as though two gigantic gates were opening. Immediately following this, the entire wall moved by sections. The total time consumed was not more than three minutes from the time I observed the first leak in the floor until the wall had moved into its final position.

SECTIONS 3 AND 4 OF BROKEN WALL WITH BROKEN FLOOR

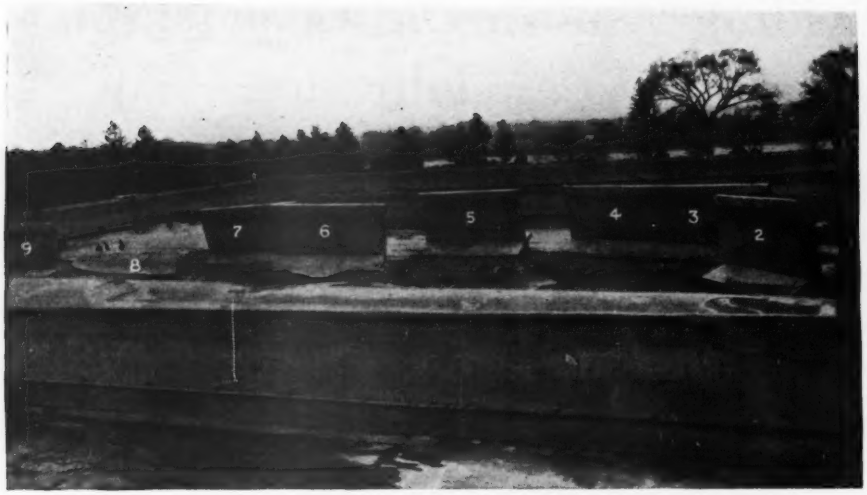
SECTION 6 OF WRECKED WALL OF COAGULATION BASIN

Note the concrete, rock and earth adhering to the base. The adhering concrete was put in to fill a cavity beneath the wall created twelve years ago when water broke through into Basin 2, when empty.

Recent Gunite Repairs—For fourteen years there has been a slight but continuous disintegration taking place in the concrete of the coagulating basins, but only within the limits of the rise and fall of the water level. The trouble was due to the alternate wetting and drying of the concrete, and frost action. In some places the disintegration was slight, but in the baffle walls, which were only 4 in. thick at the top, there were numbers of places where the concrete was entirely eaten away.

On Sept. 6, 1928, Basin No. 1 was emptied for the purpose of guniting the disintegrated strip around the walls and it remained empty until Nov. 7, when it was again put into service. Basin No. 2 was then emptied and repairs were commenced in that basin and were continued until Dec. 21, when cold weather necessitated the flooding of it for the remainder of winter. During this entire time one basin was always in service and no leaks were observed in either basin. It was for the purpose of completing the repairs begun last fall that Basin No. 2 was emptied March 22, when the failure occurred.

Previous Trouble—On one other occasion trouble was experienced with this wall. It was at a time when Basin No. 2 was emptied for cleaning eleven or twelve years ago. A considerable volume of water passed under the wall; some of it was forced upward through cracks in



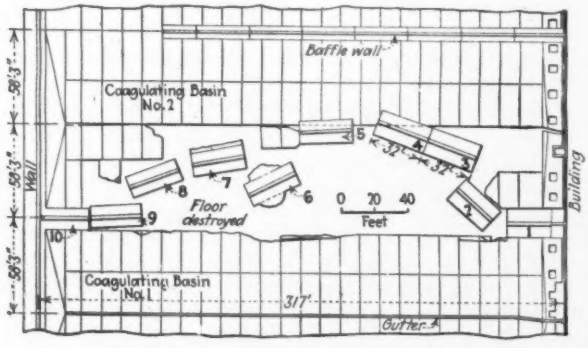
WRECKED DIVISION WALL AND BROKEN FLOOR IN BALTIMORE WATER COAGULATION BASINS

With the farther basin empty, water first burst through its floor, then swept the dividing wall forward. The numbers on the broken sections correspond with those on the accompanying plan

the floor blocks and some of it passed under the floor blocks into the center gutter. The water was immediately equalized in the two basins and afterward both basins were emptied. It was found that there were some soft spots under the wall which, after removal of the soft material, formed cavities, one of which was large enough to hold four or five men. These cavities were afterward filled with a good quality of concrete and then grout was forced under the wall base and adjacent floor slabs until each basin was watertight. The wall was not injured and the floor slabs remained in place, but an examination of the wall on the pressure side showed by the widening of one of the floor joints that the wall had evidently moved forward a fraction of an inch.

Although both of the basins were afterward frequently emptied, no sign of leakage was observed and no misgivings as to its safety were entertained.

The Coagulating Basins—There are two 8-m.g. coagulating basins at the old plant at Montebello filters, each 317 ft. long and 232 ft. wide. All walls are vertical, cantilever type, T-shaped sections. A baffle wall extends through the center of each basin to within 76 ft. of the rear wall. The floor is of unreinforced concrete 6 in. thick and has a slope of 6 ft. in the length of the basin. The outer walls are embanked with earth to within 3½ ft. of the top.



POSITION OF BROKEN SECTIONS OF WALL BETWEEN COAGULATION BASINS 1 AND 2

See corresponding numbers on the general view of the wreck.

The Wall — The division wall was 12 in. wide at the top and had a uniform batter of ⅜ in. per foot on each side. It was 14 ft. high above the base at the upper end and 19.5 ft. at the lower end. The center stem of the wall projected 2 ft. below the bottom of the base in order to provide adequate anchorage for the steel and to give an added resistance against sliding. The base varied uniformly in width from 13½ ft. at the upper end to 19½ ft. at the lower end.

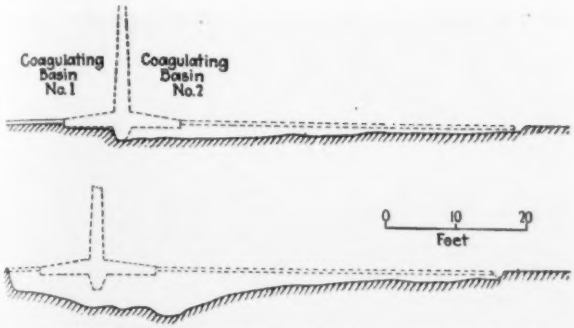
All concrete was made of a 1:2:4 mixture. A 6x6x12-in. block cut from wall section 7 after the accident and tested in the laboratory of the city Bureau of Standards failed at a pressure of 2,446 lb., and a similar block cut from a broken floor slab failed at 1,913 lb. per sq.in.

The walls were reinforced with square twisted steel bars. They were built in 32-ft. sections and were reinforced longitudinally with ½-in. bars spaced 24 in. apart on each side of the wall. The total longitudinal reinforcement was only about 0.1 per cent. After an inspection of the sections that failed, no cracks could be discovered except in section 8, which showed a diagonal crack, visible on the pressure side only, extending from a point 7½ ft. from the east and to a point about 12 ft. below the top. A ¾-in. bar taken from section 8 and tested by the city Bureau of Standards indicated an elastic limit of 42,120 and and ultimate strength of 70,890 lb. per sq.in. It was specified to withstand without fracture a bend of 180 deg. over one diameter.

As a water cutoff, ¼x12-in. expansion plates extending the full height of the wall were embedded 6 in. in each section. When the wall moved out, the plates in all cases remained securely embedded in one section. In some instances they broke the concrete from a portion of the pressure side of the adjacent section and in other instances they pulled out without fracturing the concrete at all. A careful examination of the plates showed them to be in a good state of preservation. The rusting after about fifteen years of service is so slight that it has apparently not affected their life.

If the evidence gathered by the failure of the wall at Montebello can be relied upon as typical, engineers should have little to fear from the destruction of steel expansion plates by corrosion.

Movement of Wall Sections—The wall first gave way at the joint between sections 5 and 6 and, as would be expected, the great pressure exerted on the upstream side of the wall caused serious spalling at the edge of the base. As the various sections moved forward, they pushed tons of rock, earth and broken floor slabs before them. This material caused a wedging action to be exerted on the under side of the base that tipped the top of the wall in the direction of the pressure; a direction opposite to that one would naturally expect the wall to tip. It may be of interest to note the positions of the sections that moved first. Section 5 moved about 55 ft. and section 6 about 23 ft. Section 6 was the one under which the largest cavity was found when it was pre-



TWO PROFILES OF BASIN BOTTOM AFTER FAILURE

viously repaired. Rough measurements indicated that about 120 tons of extra concrete, rock and earth adhered to the base. The section itself weighed about 130 tons and considerable earth was pushed before it. The total mass moved by the pressure exerted against this single 32-ft. wall section was from 250 to 300 tons. Section 5, which had less extra material adhering to it, advanced more than twice as far. None of the sections overturned and except for some spalling at the edges, none of them appeared to be injured.

Foundation—The material upon which the wall rested is locally known as rotten rock. When first uncovered it was hard and, in order to shape the foundation trenches, required the use of picks and mattocks. I recall distinctly that the excavation for the south wall of this reservoir stood in a vertical position for more than a year without caving, and a heavy cableway tower ran up and down a track laid near its edge. Rotten rock on long exposure to the atmosphere becomes soft but, as far as I can recall, all of the bottom was covered with concrete while it was firm and hard.

In order to test my memory as to the kind of material encountered in the foundation, I asked the contractor and three of the engineers who were very familiar with the work to write me as to their memory of the condition of the bottom. I quote below their letters:

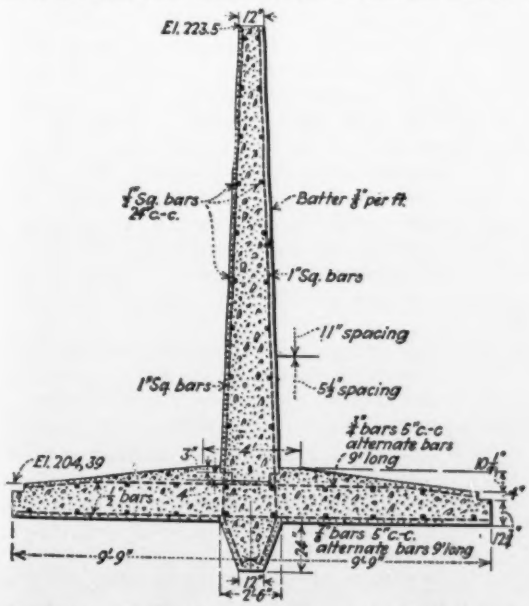
Replying to your inquiry as to my recollection of the character of the ground upon which the division wall between coagulating basins of the 1915 plant was built, I recall that the material was a compact clay which appeared to be impervious to water and a first-class material for support of the wall as designed.—(Signed) STEUART PURCELL.

My recollection is that this wall rested partly on rotten rock and partly on good stiff clay and was considered by everyone connected with the work at that time a first-class foundation for the load it had to carry. The foundation was prepared very carefully; the entire area of the foundation was brought to its final grade with picks and shovels and no backfilling done.

August Mencken, who was construction engineer for Claiborne, Johnston & Company at the time this work was done, recalls conditions as stated above and believes they are as near right as one can recall after the lapse of fifteen years.—(Signed) T. D. CLAIBORNE.

My recollection of the material upon which the foundations for the coagulating basins were placed is that this material was good firm disintegrated rock. It seemed to be very largely disintegrated feldspar, with considerable clay material in it. Just west of the basins, where the main drain from the filter plant carried, solid rock was encountered and overlying this solid rock throughout the area was a layer of disintegrated rock, the disintegration ranging from soil to rock.

The material seemed to be perfectly acceptable for the foundation purposes and there were no indications that the material would not be perfectly satisfactory.—(Signed) EZRA B. WHITMAN.



ORIGINAL CROSS-SECTION OF WALL THAT FAILED

Miami Flood-Protection Works Tested by High Flood

Moderate Rainfall in February Produced Excessive Runoff—Record Stages in Three Detention Basins

BY C. S. BENNETT

Engineer, Miami Conservancy District, Dayton, Ohio

A STORM of moderate intensity over southern and central Ohio on Feb. 25-26, 1929, produced flood conditions along several Ohio streams. The runoff from this storm in the drainage area of the Miami River provided the best test of the flood-control works of the Miami Conservancy District since their completion in 1922 and furnished an excellent opportunity further to check up on the operation of the system.

The effectiveness of the flood-control system during this storm is evidenced by the computations made to determine what the uncontrolled flow would have been at Dayton and at Hamilton, the largest cities in the district. With conditions as they were prior to construction of the works, a peak stage of about 22 ft. at Dayton would have occurred, representing a maximum discharge of about 87,000 sec.ft. This peak was reduced to 53,500 sec.-ft. (gage height 14.4 ft.), as noted below. At Hamilton the uncontrolled discharge would have been about 100,000 sec.-ft. At both cities, as well as elsewhere in the district, serious damage would have occurred, since the uncontrolled discharges would practically have equaled those of the 1898 flood, the second largest in a period of 36 years. The flood of 1898 almost topped the levees then existing at Dayton and a considerable portion of the city was inundated. Similar conditions existed at Hamilton at the same time.

Rainfall and Runoff—The rainfall in this storm averaged 1.80 in. above Dayton (2,525 square miles). Below Dayton the rainfall was greater, ranging from 2.48 in. at Dayton to 3.09 in. at Germantown dam. The ground was partly frozen and considerable snow remained on the ground in the upper part of the drainage area; during the storm and immediately thereafter temperatures were well above freezing and no doubt considerable water was released from the partly frozen soil. These facts help to explain the unusual runoff, which at Dayton amounted

TABLE I—RAINFALL AND RUNOFF AT DAYTON FOR VARIOUS STORMS

Date of Storm	Average Rainfall Above Dayton, In.	Total Runoff at Dayton, In.	Runoff, Percentage of Rainfall
1923			
March 23-27	9.60	8.76	91.0
1924			
March 28-29	2.06	1.16	56.0
June 8	2.22	1.73	78.0
1925			
September 12-13	3.20	0.04	1.2
November 12	1.43	0.66	46.0
November 26-27	1.29	0.20	15.6
1926			
April 7-8	1.23	0.84	68.0
September 22-26	2.08	0.39	18.7
1927			
January 18	1.98	1.36	68.7
March 19-21	3.44	2.31	67.0
May 18	2.05	0.61	29.8
November 30	2.15	0.64	29.8
December 13	1.24	0.64	51.6
1928			
April 21-22	2.08	0.53	25.5
June 3-6	2.86	0.46	16.1
1929			
February 25-26	1.80	2.05	114.0

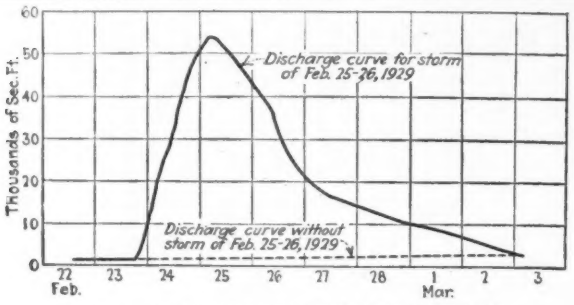


FIG. 1—MIAMI RIVER HYDROGRAPH FOR FEBRUARY STORM

to 2.05 in., or 14 per cent in excess of the average rainfall above that point. The runoff ratio exceeds those computed for such other storms as have occurred since the flood-control works have been in operation, as well as that for the 1913 storm, as indicated in Table I.

Storage in Detention Basins—All of the five dams of the district stored water after the storm, and at three of them the maximum storage and depths exceeded previous records (see Table II). It will be remembered that storage at these dams occurs automatically, there being no gates in the outlet works. At Germantown dam the maximum stage reached a depth of 54.5 ft. above outlet conduit floor, exceeding by 13.6 ft. the highest stage previously recorded. From computations made by routing previous floods (prior to construction of the dams) through the basin, it appears that the stage at Germantown on Feb. 27 exceeded by 5.9 ft. the second largest previous flood in 36 years and was exceeded only by the 1913 stage, the highest of record. However, reference to Table II will indicate that only 21.3 per cent of the storage capacity of the basin was used in the 1929 storm.

The maximum stages of 28.2 ft. at Huffman dam and 26.6 ft. at Taylorsville dam also exceeded previous records at these points since the works were completed.

River Discharge—At Dayton the maximum river stage on Feb. 27 was 14.4 ft., representing a discharge of

FIG. 2—DISCHARGE OF GERMANTOWN RESERVOIR OUTLET CONDUITS, FEB. 26, 1929

Shows effect of hydraulic pump in reducing high flow velocity. Head on conduit flow, 54.5 ft.; velocity of issuing jet at end of conduit, 43.5 ft. per second; velocity below hydraulic-pump pool, 8.4 ft. per second; discharge, 7,800 sec.-ft.

53,500 sec.-ft. This stage exceeded by 1 ft. the highest previously recorded since completion of the project. A repetition of the 1913 flood runoff would produce a stage of about 23 ft. at Dayton. The channel is designed to provide for a discharge 40 per cent greater than that of the 1913 flood, or 110,000 sec.-ft. at Dayton, with a 3-ft. levee freeboard. The maximum stage at Hamilton in the 1929 storm was 17.3 ft., which was 3.2 ft. higher than the previous record since completion of the works at that point. At a stage of 17.3 ft. at Hamilton the discharge was approximately 79,000 sec.-ft.

Observation System

The district, in co-operation with the U. S. Geological Survey, has established a number of gaging stations at various points in the Miami area, including automatic recording gages at the five dams and at Dayton and Hamilton. Streamflow measurements are made at these stations and rating curves kept up to date. A number of rainfall stations are also maintained, some in co-operation with the U. S. Weather Bureau. On the map of the drainage area (Fig. 1) are shown the stations at which records of rainfall or runoff are obtained. Seventeen of these stations report directly to the district office. Rainfalls of 1 in. or more in 24 hours are reported to the office by telephone. In major storms the various river observers and caretakers at the dams report to the office at frequent intervals, usually twice daily during the high stages.

Studies are made of every major storm that occurs. Observers at the dams read gages immediately above and below the outlets conduits at two-hour intervals from the time the conduits are half full until the stage falls again

TABLE II—CONDITIONS AT DAMS IN STORM OF FEB. 25-26, 1929

Dam	Elev. Spillway Above Conduit Floor, Ft.	Max. Stage Above Conduit Floor, Ft.	Max. Conduit Discharge, Sec.-Ft.	Total Storage Capacity, Acre-Ft.	Storage Capacity Used, Acre-Ft.	Per Cent of Total Storage Capacity Used
Germantown	91.0	54.5	7,800	106,000	22,500	21.3
Englewood	104.0	46.9	8,700	312,000	31,500	10.1
Lockington	62.0	27.0	5,300	70,000	5,000	7.2
Taylorsville	58.0	26.6	23,500	186,000	12,500	5.8
Huffman	58.0	28.2	19,000	167,000	15,000	9.0

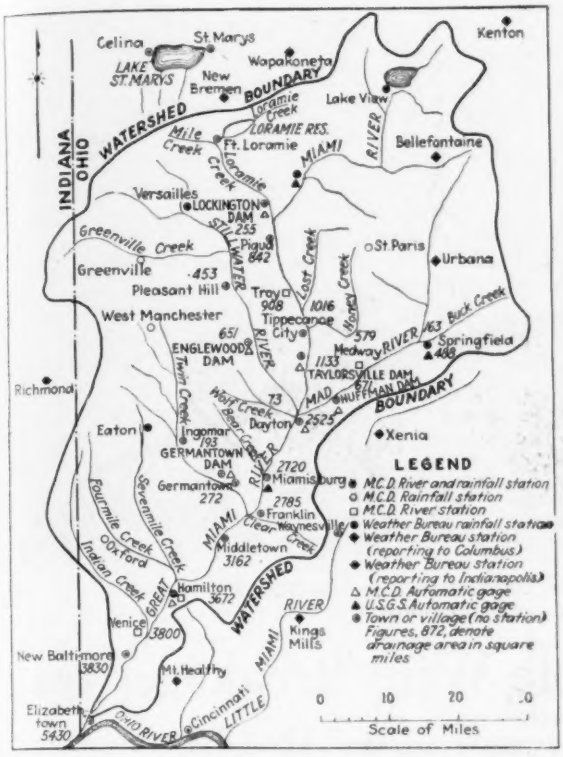


FIG. 3—GAGING STATIONS IN MIAMI DISTRICT

to that elevation. From these readings, together with topographic maps of the basins and rating curves for the conduit flow, it is possible to construct inflow and outflow curves for the storms to be studied.

Rainfall observations at the various stations are plotted on a map and rainfall contours or isohyetals are drawn for each storm. The average rainfall and runoff are computed usually only for the Dayton station. Average rainfall may be obtained by planimeter from the contour maps or by using the mean of the recorded values above Dayton. It has been found that the latter method is fairly accurate. The runoff is obtained by measuring, with planimeter, the area under a curve constructed from the river stage record at Dayton for the period of the storm. Such a curve for the storm of Feb. 25-26, 1929, is shown in Fig. 1. Maximum runoff in 24 hours may be obtained also from such a curve.

In order to gather data for computing rating curves for the conduits and at river stations, current-meter measurements are made frequently. During high stages special effort is made to secure as many measurements as possible, as the dams store water at infrequent intervals.

Special gages have been installed in Dayton and Hamilton for use during high stages in determining the water surface slope. From readings of these gages, together with measurements of actual flow at the time, calculations are being made of the roughness coefficient n in the improved channels.

Records obtained thus far have made it possible to construct discharge or rating curves for the conduits at Germantown and Englewood dams and to determine the roughness coefficient n for these conduits. As the three other dams, where the conduits have much larger areas and consequently have seldom been filled, such data have not yet been secured. A complete discussion of the results so far obtained in the hydraulic studies conducted by the district was presented by C. H. Eiffert, chief engineer, in a paper "Hydraulic Studies and Operating Results on the Miami Flood-Control System" (*Proceedings* Am.Soc.C.E., May, 1928).

An inspection of the works of the district, including the dams and channel improvements, made after the recent storm indicates that practically no damage was suffered by any of the works, except for slight scour along some of the levee slopes and some damage to a section of old stone revetment on Mad River which was placed many years ago.

Bureau of Standards Uses Hot Wire to Measure Wind Velocities

A hot wire is now being used to measure wind velocities at the Bureau of Standards, according to the Department of Commerce. Measurements are made by the use of a fine electrically heated wire about one-fifth the diameter of a human hair and a five-tube amplifier, the winds to be measured being produced in wind tunnels.

FIG. 4—MAD RIVER BELOW HUFFMAN DAM, FEB. 27, 1929
Automatic recording gage is housed in concrete structure in foreground. Discharge is being measured from cableway. A similar installation is at each dam.

FIG. 1—THE MOUNT HOPE BRIDGE ON FEB. 23 JUST AFTER DISCOVERY OF BROKEN WIRES
Preparations were under way for placing concrete floor slab.

Technical Aspects of Cable Wire Breakages on the Mount Hope Suspension Bridge

Breaks Localized in Strand Shoes—Progressive Breaking Noted in Spite of Load Reduction—Cable Spinning Methods—Characteristics of Wire and Its Manufacture—Temporary Repair Measures

WIRE breakages in the cables of the Mount Hope and the Detroit suspension bridges which resulted in decisions to replace the cables on both bridges with new ones (*Engineering News-Record* March 28, p. 516, and April 4, p. 564) represent the first serious failure of bridge suspension systems recorded in modern times. As noted in our previous issues, the wire was new and untried in suspension structures, so that its failure has no bearing on the safety of suspension bridges now in place or under construction. However, because of the constant and continuing desire to develop new materials with high stress characteristics, of which this wire was one example, it is quite necessary to review the circumstances surrounding these wire breakages in detail. This article covers certain technical aspects of the situation at Mount Hope, including the discovery and location of wire breakages and the methods of repair, a review of the wire specification, including the origin of its acceptance and some of the preliminary test studies, a description of the cable-spinning methods used and a résumé of the wire-manufacturing process.

Description of the Bridge—The Mount Hope bridge is a private toll highway bridge of the suspension type located across an arm of Narragansett Bay in Rhode Island some 15 miles south of Providence. It runs in a north-south direction with the towns of Bristol and Portsmouth near its north and south ends respectively. It has a 1,200-ft. main span with 135-ft. channel clearance and 504-ft. side spans. From cable bents placed at the ends of the side spans, the cables slope down sharply to the anchorages. The length of the bridge from anchorage to anchorage is 2,648 ft. The structural steel towers are 284 ft. above mean low water and are of the fixed-base flexible type.

There are two 11-in. wire cables 34 ft. apart, each consisting of seven strands of 350 wires (No. 6, heat treated and galvanized) having a theoretical diameter of 0.196 in. and providing a total cross-section per cable of 74 sq.in. Actually the wires ran somewhat under the theoretical cross-section and several more than the 350 wires were included in most of the strands. The seven strands are arranged in three tiers, two strands on the top, three strands in the center and two strands in the bottom tier (Fig. 5, center).

The wire specification was originally drafted for cold-drawn wire but was subsequently changed to admit a new type of wire hardened by heating and quenching after the wire drawing. The specification stipulated that check analyses of the finished or semi-finished wire should not show in excess of 0.935 per cent carbon, 0.05 per cent phosphorus and 0.05 per cent sulphur. The diameter of the wire before galvanizing was specified as 0.192 in. with 0.003 in. tolerance, and after galvanizing as not more than 0.005 in. larger in diameter than the bright wire. The specified bend tests required that the wire bend continuously around a mandrel 2 in. in diameter without developing cracks in the galvanizing visible to the naked eye, and that it bend continuously around a mandrel of four diameters without sign of fracture. The ultimate strength was placed at 220,000 lb. per sq.in. minimum on the gross cross-section, the elongation at 4 per cent in 10 in., the reduction in area at 30 per cent and the yield point at 190,000 lb. per sq.in., the yield point being defined as the point where the elongation

of the specimen in a 10-in. gage length is 0.75 per cent. The test for yield point was required to be made on samples taken from 10 per cent of the coils manufactured.

The heat-treated wire was first adopted for use on the Detroit bridge following studies and tests made by its engineers. Later, after work had been started on the Mount Hope bridge and following special recommendations, the new wire was substituted for the cold-drawn wire originally provided for in the specifications. It is understood that the manufacturer planned to subject to a magnetic analysis about 2 ft. of every 30 ft. of the wire manufactured, and to safeguard the manufacture in every way possible. In spite of these assurances and the promise of increased efficiency, the engineers for the Mount Hope bridge declined to dispense with any of the original number of wires in the cables, as is understood to have been done on the Detroit bridge, electing rather to give to the Mount Hope bridge a 10 per cent greater efficiency without additional cost.

Construction of the bridge was begun in the early spring of 1928 and rapid progress had been made toward meeting the opening date of July 1, 1929. The cables were spun in September and October, 1928. The main and side-span stiffening trusses and the floor system were completed Jan. 15, 1929. An article on the design of the Mount Hope bridge appeared in *Engineering News-Record* April 12, 1928, p. 585.

Early in February, at the time of the discovery of the first breaks in the wire, the bridge was completed to the extent shown in Fig. 1. Forms and reinforcing steel in considerable quantities were in place for pouring the concrete floor and the cables were stressed to about 32,000 lb. per sq.in.; their ultimate working stress was to be 80,000 lb. per sq.in.

Discovery of Breaks—During the handling and spinning of the cables nothing unusual occurred. Three broken wires were noticed in January, six on Feb. 8 and eleven additional on Feb. 19. All of these breaks were at the strand shoes (as were later breaks) at or close to the point of tangency of the wire to the curve of the back of the shoe; they did not affect any one strand but were scattered among the 28 shoes of both anchorages.

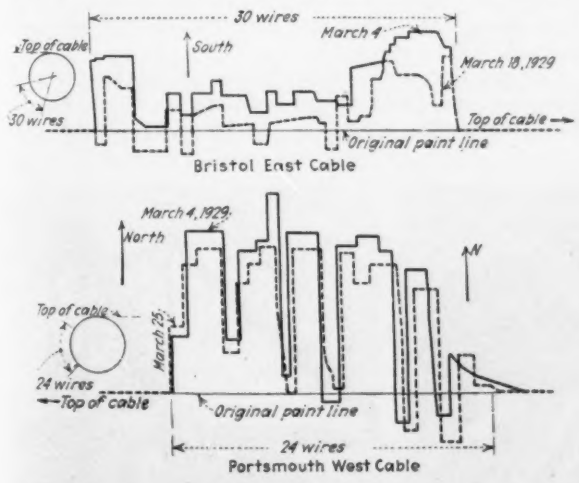


FIG. 2—CABLE SLIPPAGE DIAGRAMS FOR POINTS OF GREATEST FAILURE

Solid lines represent total recorded slip from a paint line applied on Feb. 23 just above the splay casting. Dotted lines show position of wires after hairpins were applied and slipped wires pulled back. Diagram for Portsmouth West cable probably shows all slippage, while at Bristol East anchorage considerable slippage had already occurred when the paint band was applied.

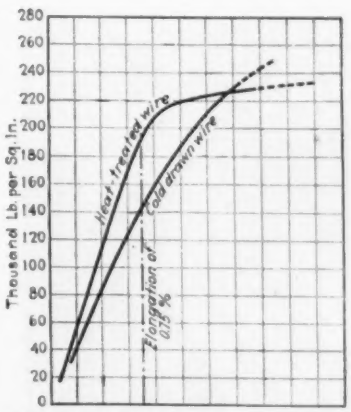


FIG. 3—COMPARATIVE SHAPE OF STRESS-STRAIN CURVES OF COLD-DRAWN AND HEAT-TREATED CABLE WIRE

Note abrupt change in the slope of the curve for the heat-treated wire at about 85 per cent of ultimate strength.

No particular anxiety appears to have been felt at this time, as the placing of floor forms and reinforcing steel was continued several days longer. But on Feb. 22, a holiday when work was shut down, 65 broken wires were discovered in the Bristol anchorage in the east strand of the bottom row of the east cable. On Saturday, Feb. 23, a more careful examination of the same strand was made, which showed that about 75 per cent of the wires in that strand were broken near the shoe. No additional breaks were found in any of the other anchorages.

Work Stopped—Work was immediately stopped. In order to detect any slippage occurring, on Feb. 25 bands of red paint were placed around the cables just ahead of the splay castings and also on each strand just behind the splay castings. It is probable that by this time considerable wire slippage had occurred on the bad strand at the Bristol East anchorage, but it is believed that at Portsmouth the paint band was in place before any breaks occurred. The maximum slippage subsequently measured at the Bristol end was about 1½ in., while that at the Portsmouth end was 3½ in. The slippage diagram for the Portsmouth West cable shown in Fig. 2 is a fairly accurate picture of the total slippage occurring in this cable. A similar slippage diagram is shown for the Bristol East cable. These diagrams cover a group of 25 to 30 wires on the outside circumference and are thus merely indicative of what may have happened within the strand. The painted lines on the Portsmouth East cable and the Bristol West cable showed that no appreciable slippage occurred there and the absence of breaks in these anchorages verified the fact.

On Feb. 27, ten broken wires were located at the Portsmouth West anchorage, all in one strand, and at the Portsmouth East anchorage one new break was located in addition to one previous break. Following a careful inspection on Feb. 28, made by pulling each wire with a hook inserted into the different strands, 77 additional broken wires were found at Portsmouth West. Additional broken wires were discovered on March 1, and further ones on March 2. On March 11, 90 tons of reinforcing steel was removed from the main span and on March 3 as much snow as possible was removed.

On March 4 a check on the damaged strand in the Bristol East anchorage showed that a total of 140 wires were broken. On the same day the final count in the Portsmouth West anchorage showed that 130 wires were broken, thus affecting 260 wires out of 360 in the strand (east strand of middle tier).

On March 9 numerous other breaks were discovered at the Portsmouth end. In Portsmouth East sixteen breaks were discovered in one strand and fifteen breaks in another strand. In the Portsmouth West anchorage eight new breaks were found.

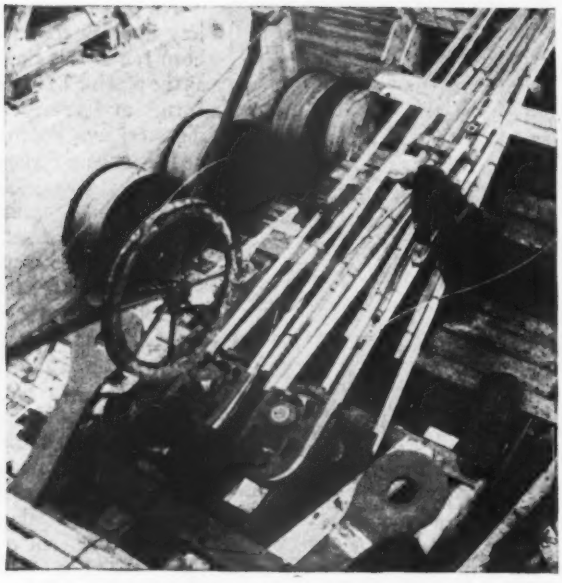


FIG. 4—SPINNING CABLE IN THE BRISTOL WEST ANCHORAGE

Note pulley sheave on lower left of strand shoe around which each wire was preformed so that it would lie flat around the shoe. Traveling wheel is ready to leave anchorage with a bight of wire to be carried to the opposite side.

On March 13 an examination of the outside surface of the cables for their complete length was made and one break was found in the west cable of the Bristol backstay about 10 ft. from the face of the cable bent saddle. This is believed to have been an old break made during cable squeezing.

Repairs—Repair work was immediately begun following the discovery of the first breaks. Precautionary measures consisted in removing the reinforcing steel, 90 tons, and later the floor forms from the bridge, also in painting the red bands around the cables to keep a check on cable slippages. Splicing the breaks began soon after Feb. 23, and by March 3 a number of wires had been repaired. This work was done by inserting "hairpins" around the shoes, splicing them to the ends of the broken wires on each side. These hairpins were made of cold-drawn wire in about 20-ft. lengths and were applied as fast as possible by a crew of men working 24 hours a day. Hairpins had been attached to all broken wires by March 15 and strain-gage readings on some of them showed a stress of 1,200 lb. per wire. In addition to the actual repair of the breaks, temporary hold-back cables were placed on both ends of the bridge between the cable bents and the anchorage eyebars.

In the foregoing account of the cable wire breakages several significant points are to be noted. In the first place, the majority of the breaks occurred in two strands, one in the east cable and one in the west cable. In the east cable the breaks were localized in the Bristol anchorage very near the tangent point on the strand shoe. In the west cable the breaks were localized in the Portsmouth anchorage, but also near the tangent point. In the Bristol anchorage about 75 per cent of the total number of wires in the strand were broken, while in the Portsmouth anchorage it is stated that 130 wires out of a total of 180 in a half-strand were found broken.

Another point to keep in mind is that on March 9, two weeks after the first breaks were discovered, eight additional breaks were found in the Portsmouth West anchorage and 31 breaks in the Portsmouth East anchorage; in the latter only two breaks had been discovered previously. Since careful inspection had been made of all cables daily since the first breaks were discovered, these additional breaks were evidently new ones. In the two-week interval no additional loads had been placed on the bridge—in fact, some 90 tons of reinforcing steel had been removed and in addition the snow load had either been removed or had melted.

Characteristics of Cable Wire—Utilization of heat-treated wire in the Mount Hope bridge, following its adoption for use in the Detroit bridge, marks the introduction of this type of wire to suspension bridge service. The ultimate strength of the heat-treated wire (about 220,000 lb per sq.in.) is not appreciably above that of wire which has been used heretofore. The cold-drawn wire in the Manhattan bridge has an ultimate strength of 210,000 lb. per sq.in.; the specifications for the Philadelphia-Camden bridge raised the requirement to 215,000 lb. per sq.in. On the Fort Lee bridge, now under construction, the ultimate strength is designated as 220,000 minimum and 225,000 average. The wire of these bridges is galvanized; that of the Williamsburg bridge is bare or bright. On the Portsmouth (Ohio) bridge galvanizing was omitted and the wire supplied averaged over 230,000 lb. per sq.in.

Comparative stress-strain curves of the heat-treated wire and cold-drawn bridge wire are shown in Fig. 3. The yield point, taken (by specification) as the load

FIG. 5—THREE VIEWS OF THE CABLE-SPINNING OPERATIONS ON THE MOUNT HOPE BRIDGE

At left—Arrangement of equipment in the Bristol East anchorage showing reels of wire in reel frames; extra reels in pit at right. Center—Adjusting wires for sag. Note arrangement of strand shoes in three tiers. Right—Traveling wheel running on endless hauling cable and bringing a bight of wire from the far shore.

necessary to cause 0.75 per cent elongation, is about 190,000 lb. per sq.in. for the heat-treated wire and about 145,000 lb. per sq.in. for the cold-drawn wire. Tests are also reported to have demonstrated that the heat-treated wire has the high modulus of elasticity of 29,000,000, as compared with about 25,000,000 for cold-drawn wire. The manufacturers claim for the heat-treated wire a reduction in area of between 30 and 50 per cent.

Because of these qualities several advantages have been claimed for the heat-treated wire. In the first place, because of its high elastic limit, it is not given a permanent set when wound on 5-ft. blocks for shipment; conversely, when unwound it will lie straight on the ground. This feature was pointed out as contributing to ease of erection and as insurance against internal stress when the wire was laid up in the cable. Another claimed advantage was that the increase in strength below the yield point makes possible the use of higher working stresses than have heretofore been used. Also, because of the increase in the modulus of elasticity, these higher stresses could be used without increasing the deflection.

Cable Spinning—Cable spinning began on Sept. 10, 1928, and was completed on Oct. 25, 1928. The method used included several important innovations: (1) spinning directly in the permanent saddles, both on the main towers and the cable bents, rather than in temporary saddles from which the completed strands must be hoisted into place; (2) installing the anchorage eyebars in a flat rather than in a vertical position as on previous bridges; since cables are always spun with the shoes in a horizontal position the above practice eliminated the necessity for turning the shoes 90 deg. to attach them to the eyebars as would be necessary if the eyebars were vertical; and (3) preforming the wires as they passed around the strand shoe by bending them sharply around a small diameter sheave.

The equipment for cable spinning did not differ appreciably from that used on previous suspension structures. The footbridges were hung so as to give a continuous walk from anchorage to anchorage 5 ft. below the main cable curve. An endless hauling cable of wire rope was installed passing around large horizontal wheels at each anchorage, the wheel at the Bristol anchorage being driven by a 50-hp. motor and the one at the Portsmouth anchorage serving as an idler. Wooden bents fitted with sheaves and located at 250-ft. intervals along the footwalk supported the hauling cable. Two traveling sheaves or wheels were attached to the hauling cable at such a distance apart that they would pass in the center of the main span and each reach the side opposite from which it started at the same time.

Two reel frames holding two reels each were mounted on each anchorage. Each traveling wheel on the hauling rope carried a bight of cable wire from one reel across the footbridge, spinning two wires in each strand, and then returned with a bight of wire from the reel on the opposite anchorage, spinning two wires in a second strand. In this way two strands of each main cable were spun simultaneously.

The traveling wheel when coming into a strand shoe released the wire to the shoe as soon as the line end was clamped. A man stationed at the shoe then bent the free end of the wire around a 9½-in. diameter sheave (visible on top of the shoe in Figs. 4 and 5). This bending gave the wires a permanent set, and since the bending was done in a complete circle of half the diameter of the 19-in. shoe, the wire should upon release exactly conform to the lower half of the strand shoe. The lengths

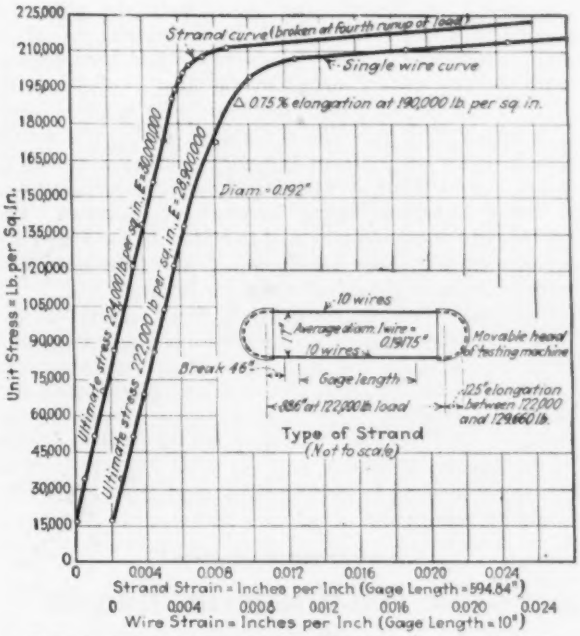


FIG. 6—STRESS-STRAIN DIAGRAMS OF A TWENTY-WIRE STRAND AND OF AN INDIVIDUAL WIRE (FROM PRELIMINARY SHOP TESTS)

of the strands were regulated by wedges in the strand shoes moved by hydraulic jacks. Tension during spinning was controlled by hand brakes on the wire reels.

Wire Manufacturing—In the manufacturing process, which is said to be continuous, the wire after drawing is passed through a lead bath and oil quenched, the galvanizing process following as an integral step in the manufacture. It is understood that the cold wire is first subjected to a normalizing process in which it is heated in lead to a temperature well above the critical range and then quenched in another lead bath at a temperature well below the critical range. The wire is then again heated in a lead bath to the proper temperature for hardening, quenched in an oil tank and as a final heating operation is tempered in another lead bath to remove the oil. Following this the wire is washed, cleaned and galvanized in the usual way and wound upon blocks 5 ft. in diameter.

It is understood that any length of wire required may be manufactured, since electric welds after being subjected to the heat treatment have shown a strength and ductility approximating that of the rest of the wire.

Test Results on the Wire—Data on some of the tests which were made prior to the adoption of the wire for the bridge are available. All show uniformly high results.

During the development of the wire magnetic analyses were made, utilizing an oscillograph for recording the results, and unusual uniformity of the wire was noted. The coils of wire which showed good magnetic analysis were later tested in 3-ft. lengths and showed uniform properties of tensile strength, elongation and reduction in area. In addition to these tests, long lengths of the wire were wound into close spirals and no brittle spots were disclosed in wire which showed a good magnetic analysis.

In Fig. 6 are shown the stress-strain diagrams of a strand containing twenty parallel wires of No. 6 gage and of a single wire from the same coil, the data originating in a shop test made in May, 1928, to determine the modulus of elasticity. The wire in the strand was approximately 2,000 ft. long and was cut from a coil which had been rejected because of a rough coat of gal-

vanizing. To manufacture the strand, the wire was looped back and forth around the testing machine shoes until a loop of ten wires cross-section had been formed with the two ends fastened to the shoe on the movable head. The strand was bound loosely by hand at intervals of about 10 ft. The shoes were 17 in. in diameter and in order to preform the wire so that it would fit snugly about them, it was first wound by hand around a sheave of 6¾-in. groove diameter for 1¼ turns. The preforming operation was said to eliminate the secondary stresses at the shoes which would have produced distorted results in the initial stages of loading.

The test procedure consisted in three run-ups of the load, dropping back to zero each time, the last run-up being followed by the additional loading necessary to cause the strand to reach the breaking point. Load and elongation readings were made on each run-up for increments of 10,000 lb. The first run-up reached 60,000 lb., the second 80,000 lb. and the third 79,980 lb. The last step consisted in loading the strand from 80,140 lb. to the breaking point of 129,660 lb.

Private Toll Bridges in Disfavor in California

THE BUILDING of private highway toll bridges in California should be prohibited, according to a recommendation by the California State Highway Commission after a study of such structures throughout the state extending over a two-year period. This investigation, which was authorized by the 1927 state legislature, resulted in the recent publication of a 140-page report presenting several general conclusions supported by detailed statistical data on the financing and construction of toll bridges by private capital. The report recommends that the Highway Commission or the director of public works be empowered by law to acquire by purchase or by condemnation all privately owned toll bridges in the state.

The general finding is made that the cost and resulting toll charges in the case of the private toll bridges are higher than they would be for similar state-built bridges and that in addition there is a serious lack of conformity to the plans for a state highway system. Anticipated profits from promotion fees, contracts and tolls based on expected future traffic often inspire private promotion, it is charged, at locations where traffic does not justify a bridge. However, the conclusion is also drawn that private interests are apt to recognize the necessity of bridges at strategic points where public officials fail or are slow to see the need.

As a substitute for private toll bridges the report recommends that the state or county be empowered to finance and build toll bridges by the issuance of bonds payable through the income from such structures. Regarding the acquisition of existing privately owned bridges the report finds that condemnation affords the only means possible because of the intricate problem of fixing equitable value. The estimated cost of acquiring the present five toll bridges and one toll road in California is $20,156,300 based on the cost of the projects to the toll companies. The cost of reproducing similar bridges by the state is estimated to total $16,215,900.

More definite statistical data of the report in regard to the actual bridges studied are given in the following:

Promotion and organization are found to constitute a major expense item of the privately owned toll bridges. These costs in the case of the Carquinez and Antioch bridges, owned and operated by the American Toll Bridge Company, were found to total $1,156,776, as compared with an estimated promotion and estimated organization expense of $153,500 under state construction and finance. Similar expense items in connection with the San Mateo-Hayward bridge, including money and stock allotment, indicate a total of at least $785,670, compared with an estimated charge of $160,000 in the case of state construction for the same bridge.

The financing charge for the privately owned toll bridges studied is also declared excessive, particularly in regard to stock bonuses and interest charged on bonds. Financing of the Carquinez and Antioch bridges included a stock bonus of 500,000 shares and a $673,853 item for bond discounts. Investigations indicate that all of the 120,000 shares of common stock of the San Mateo-Hayward bridge had been issued to those directly interested in the project for services rendered without actual capital investment of money.

The interest paid for bond financing was found to average 7.7 and 8.7 per cent for the two largest bridge companies, including bond discounts and an estimated return on stock bonuses. In comparison, the interest rates on capital for state-built structures are estimated to be 4½ per cent for state bonds sold at par or 6 per cent if bonds were secured by the income of the bridge built under public control.

The cost of constructing privately owned toll bridges was estimated to be from 10 to 25 per cent higher than for constructing similar public structures, principally due to lack of competitive bidding on the contracts. As a direct result of high expenses and cost the rate of tolls on private bridges is higher than would be necessary to operate and amortize the cost of state-built structures.

The public owns and operates 95 per cent of California's roads and bridges through state or county agencies. "It should not be necessary nor should private capital be allowed to pick out advantageous points on the highway system and build toll roads or bridges that will take profit that would otherwise tend to lessen the average cost of highway service on the entire public highway system. . . . The present enormous investment by the public in state and county highways is being capitalized by private toll bridge companies."

The steps necessary to make possible complete public control of toll bridges, primarily of a legal nature, are outlined in the following: The existing laws governing the issuance of franchises for toll bridges by delegating authority to counties are obsolete, inconsistent with the present idea of a state highway system and should be changed. The right to grant franchises either should be vested in the California Highway Commission or be made with the approval of that body, and the rates of toll should be under the jurisdiction of the California Railroad Commission.

Power should be given by law to the Highway Commission or to the director of public works to "locate, design, construct and operate" toll bridges and finance the same by issuing income bonds having as their sole security the income from tolls. The entire income from tolls, after deducting necessary expenses, should be used to amortize the cost of the structure, after which the bridge would be made free.

The investigation was made under the direction of C. H. Purcell, state highway engineer, and Charles E. Andrew, bridge engineer of the division of highways.

Letters to the Editor

Another Cellular Concrete Arch Bridge

Sir—In your issue of March 14 there is a description of a test of a cellular concrete arch, in which the author states that to his knowledge no cellular arch has been built in this country. The Ninth St. Bridge, over Chester River in Chester, Pa., built in 1926, is a cellular arch of 160-ft. span, 15 ft. rise, complicated by a skew of 43 deg. The arch slabs are generally 1 ft. thick. The longitudinal ribs, 18 in. thick, are 11 ft. apart. It was designed by S. C. Hollister. The writer was resident engineer. G. D. HOUTMAN.

Media, Pa.
March 18, 1929.

Hydraulic Laboratory Practice

Sir—In your issue of Dec. 20 last Clemens Herschel in his review of "Hydraulic Laboratory Practice," edited by John R. Freeman, says: "Historians are already tracing the history of hydraulic laboratories to Engels' river improvement laboratory of Dresden and of 1893." In reviewing the great developments in this field made by the Germans and others it is easy to overlook the early but original work done in this field by Osborne Reynolds, professor of civil engineering in Owens College, Manchester, who, when consulted with regard to hydraulic problems connected with the construction of the Manchester Ship Canal, constructed in 1883 or 1884 a model of the estuary of the Mersey on a horizontal scale of 2 in. to a mile and a vertical scale of 1 in. to 80 ft., in which artificial tides were produced every 42 seconds.

A former distinguished pupil of his (now Professor), A. E. Snape, has told me that this model was the first of the sort ever made and was the means of solving definitely problems the answer to which would otherwise have been only a matter of opinion. J. D. SHANNON,
Consulting Engineer.

Cape Town, South Africa,
Feb. 15, 1929.

Analysis of Continuous Foundation Beams

Sir—In the issue of *Engineering News-Record* for Aug. 16, 1928, there was published an article in which the writer developed a new method for the analysis of continuous foundation beams, considering the system as statically determinate. In a letter that appeared in the issue for Aug. 30 it was contended that the writer's assumption of uniform soil pressure is inconsistent with the existence of predetermined column loads. In other words, the soil pressure will be so distributed along the beams that the reactions at the supports, as computed by the theorem of three moments, will be equal to the given column loads. This line of reasoning, which is a sort of inverse application of the continuous beam theory, has also come to the writer's attention from another source, leading him to the conclusion that it suggests itself naturally in this problem and should be answered.

There is no mysterious property of the theorem of three moments by which it controls the distribution of the foundation stress or pressure. The latter is a function simply of the compression or deformation of the soil, and this in turn is controlled by the settlement of the beam from point to point in its length.

The distribution of the foundation pressure is dependent upon the relative stiffness of the beam and the soil. Let us consider two extreme cases. If the beam rests upon a perfectly rigid foundation there will be no lateral distribution of pressure by the beam and all the reaction will be concentrated directly under the columns. The beam will in this case be subjected to no bending stress whatever. On the other hand, suppose that the beam is supported upon a bed of long and flexible springs. In this case the upward pressure on the beam will be very nearly uniform along its length, and if the beam was rigid it would be exactly uniform (providing, of course, that the center of gravity of the column loads coincides with the center of gravity of the footing). These two cases represent ideal conditions, but it is the writer's belief that the average soil on which a spread footing is used and the usual deep and stiff foundation beam give a combination that rather closely approaches the second case.

In order to check the above conclusion the writer has computed the maximum deflections for a reinforced-concrete foundation beam of 12-ft. span under a net foundation pressure of 3 tons per sq.ft. and for the case of an exterior and an interior span. The former was considered as a beam fixed at one end and supported at the other, while the interior span was taken as fixed at each end. The beam was taken as 18 in. wide and with stresses of 650 lb. per sq.in. in the concrete and 16,000 lb. per sq.in. in the steel the effective depth figured as 24 in. for the exterior span, with a corresponding steel area of 2.16 sq.in. The beam for the interior span was given the same dimensions (as would be the case in practice) and the steel area figured out 1.29 sq.in.

Employing the theory presented in "Principles of Reinforced-Concrete Construction," by Turneaure and Maurer, the center deflections were 0.0246 and 0.0123 in. respectively.

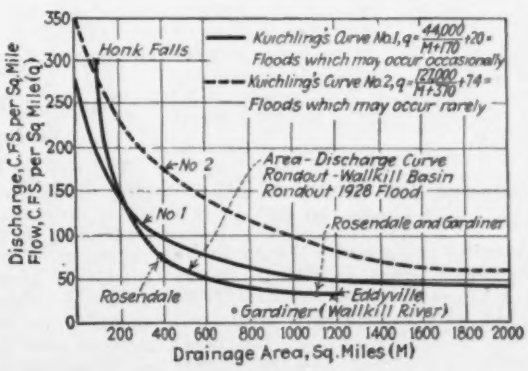
The next step is to compare these deflections with the settlement that might reasonably be expected for a soil which is carrying a load of 3 tons per sq.ft. In *Engineering News* for May 7, 1914, there is an article by M. W. Manz in which he reports a series of soil tests. On a fine, dry sand a load of 6,000 lb. per sq.ft. produced a settlement of $\frac{3}{8}$ in. in six days; a mixed sand and gravel gave $\frac{5}{32}$ in. in the same time and a fine gray water sand gave $\frac{1}{8}$ in. A moist blue clay settled 1 in. in six days, but this would certainly not be loaded as high as 3 tons in practice. In *Engineering and Contracting* for October, 1923, Charles Evan Fowler reports loading tests on Detroit clay. On dry clay a settlement of $\frac{1}{8}$ in. was produced by 6,000 lb., while on a soft clay a load of 5,500 lb. acting for a period of 73 days produced a total settlement of $\frac{1}{4}$ in.

If we assume a minimum settlement of $\frac{1}{8}$ in., the reduction in foundation pressure at the center of an interior span due to deflection of the beam is only about 10 per cent and for an exterior span 20 per cent. The corresponding values for a maximum settlement of $\frac{1}{8}$ in. are about 3 per cent and 6 per cent respectively. NORMAN B. GREEN,
Structural Engineer.

San Francisco, Calif.
Feb. 6, 1929.

Data of a Cloudburst Flood in Rondout Creek

Sir—With reference to my article on the Rondout flood in *Engineering News-Record* of March 7, I note that the area-discharge curve of the Rondout-Wallkill basin is located incorrectly with respect to Kuichling's curves 1 and 2. The Honk Falls discharge of 300 sec.-ft. per square mile should be plotted against a drainage area of 102 square miles and not zero. The attached chart shows the curves correctly.



Through an oversight I neglected to state in the article that the streamflow stations at Gardiner and Rosendale are rated by the U. S. Geological Survey from current meter measurements made by its engineers working out of the Albany office, under A. W. Harrington, district engineer. These stations furnished an important check on our flood flow estimates. E. A. VAN DEUSEN,
Hydraulic Engineer.

Poughkeepsie, N. Y.
March 12, 1929.

News of the Week

Major Edgerton Transferred to Duty at West Point

After having served for five years with the Federal Power Commission, Major Glen E. Edgerton has been ordered to the U. S. Military Academy to serve as an instructor of civil and military engineering. He is to be succeeded by Col. Max Tyler.

Before becoming chief engineer of the commission Major Edgerton occupied the office of assistant chief. In that period he supervised the engineering and economic work during more than half the life of the commission since its organization in 1920.

Before going to the Federal Power Commission, Major Edgerton was for two years the director of sales for the War Department. He served five years as chief engineer of the Alaskan Railroad Commission and two years on the Panama Canal. In addition to his duties as chief engineer of the Federal Power Commission, Major Edgerton also served as a member of the Board of Engineers for Rivers and Harbors. As Colonel Tyler will not be able to take over the position until the middle of August, Major Edgerton will not assume his new duties at West Point until Aug. 24.

Idaho to Spend $2,000,000 for Bridge Construction

An expenditure of $2,000,000 is planned by the State of Idaho for bridge construction during the coming season. The bridges proposed, together with the amounts allocated for their cost, follow: across the Coeur d'Alene River at Harrison, $250,000; Clark's Fork River at Sandpoint, $300,000; Salmon River at Goffs, $100,000; Snake River, connecting Idaho and Washington at Porter's Ferry, $175,000; Snake River between Lewiston and Clarkston, co-operating with the State of Washington, $475,000; Kootenai River at Bonner's Ferry, $250,000.

Bridge Pier Moves 22 Ft. and Settles 20 Ft.

Scouring and pressure due to an ice pack caused serious trouble, in March, to the Great Northern Railway bridge crossing the Columbia River at Marcus, Wash., on the branch from Marcus to Oroville. This bridge consists of nine timber Howe-truss spans of 150 ft., with pile trestle approaches, the total length of the structure being 1,389 ft. The truss spans are supported on piers of timber frame construction, built on timber piling and protected by rock-filled cribs. The ice pack caused scouring of the riverbed near one of the piers supporting the adjacent ends of two truss spans. This pier moved out of line about 22 ft. and settled a maximum of nearly 20 ft. at the downstream end. The movement did not take place suddenly, but continued at a rather uniform rate for several days. It was necessary to construct false piers on each side of the displaced pier. The spans were jacked back into line and surface and are now supported on the false piers. It is planned to rebuild the pier, using the same type of construction, but the piling will be driven to a greater depth and protected with riprap to prevent scour. The major portion of the pile-driving for the false piers and protection work was done under contract by Dibblee Brothers, Spokane, Wash. The remainder of the work is being done by the railway company's forces, under the direction of J. R. W. Davis, chief engineer, and H. S. Loeffler, bridge engineer, Great Northern Railway.

Great Northern-Western Pacific Seek Connection in Oregon

Applications for permits to build a 200-mile connecting link between the Great Northern Railway and the Western Pacific Railroad in northern California and southern Oregon are before the Interstate Commerce Commission. Hearings are scheduled to be held in San Francisco during July.

The Great Northern was authorized by the commission in 1928 to extend its service to Klamath Falls, in southern Oregon, as noted in *Engineering News-Record*, May 10, 1928, p. 737. The Western Pacific present main line extends north and east from San Francisco Bay to its most northerly point in California at Paxton, where it turns east into Nevada. The distance from Klamath Falls to Paxton is about 200 miles and the two systems propose to extend their tracks in both directions, meeting near Lookout, Calif.

Tacoma, Wash., Plans New Storage Reservoir

The city of Tacoma, Wash., has applied to the Federal Power Commission for a preliminary permit looking to a future step in its plan of municipal development. The application covers a site on the south fork of the Skokomish River 15 miles northwest of Shelton, where it is proposed to construct a masonry arch dam 280 ft. high and an earthern dike to form a storage reservoir with an area of 1,800 acres. From this reservoir it is planned to drive a 3½-mile tunnel to connect with Cushman reservoir No. 1, now a part of the applicant's system. The water thus added to the Cushman reservoir will be utilized through existing and prospective power houses. The new site is expected to develop 39,100 hp.

Youngstown's Rainfall and River Stage Highest Since 1913

Heavy rain in the Mahoning and Shenango valleys, Ohio, April 4 and 5, caused extensive minor damage. At Youngstown, according to observations made by W. I. Van Arnum, chemist, city water-filtration plant, and transmitted to *Engineering News-Record* by W. H. Dittoe, chief engineer, Mahoning Valley Sanitary District, 2.8 in. of rain fell during the 24-hour period ended 8 a.m., April 5, while at Warren the precipitation was 1.2 in. The Youngstown rainfall was the highest recorded since March, 1913, when the record for three days ended at 8 a.m. was: March 24, 1.02 in.; 25th, 2.96; 26th, 0.28; total, 4.26 in.

The river stage at Youngstown at 10 a.m., April 5, 1929, was 9.6 ft. above normal, having risen from 1.6 ft. overnight. In 1913 a stage of 22.8 ft. was reached on March 26. Although the river stage on April 5, 1929, was the highest attained since 1913, there had been several other stages approaching 9.6 ft. in between.

At Youngstown, low areas along Crab Creek suffered from flooding, while in various parts of the city sewers were surcharged and washouts occurred, with some property damage.

J. J. Mantell to Americanize Chinese Railways

J. J. Mantell, formerly vice-president of the Erie Railroad, has been named as consulting manager of the Chinese railways. American railroad men were consulted by the nationalist government of China with regard to the Americanization of their railroads, and Mr. Mantell was selected to make a survey and report to the government on the costs involved and the savings to be realized through their reorganization on American lines.

Mr. Mantell was born in Elmira, N. Y., 44 years ago. He entered the employ of the Erie Railroad in the engineering department, and advanced to the position of vice-president. He was in charge of rail facilities used in the movement of 1,650,000 troops through the port of New York during the war.

High Water Breaks Dikes in Detroit

High water from the Detroit River, caused by the heavy rain, caused breaks on April 5 in the privately built dikes protecting low-lying sections of the city. About twenty blocks were flooded. During the high water the sewers and pumping stations operated satisfactorily.

Lake Pleasant Dam Gets $175,000 Emergency Appropriation

On Feb. 21 the Governor of Arizona signed an act that previously had passed both houses of the state legislature, appointing a board of reservoir control and supervision whose function it is to protect life and property from the menace of dams and reservoirs that may become dangerous. The act declares that an emergency exists and carries within it an appropriation of $175,000 from Arizona's general fund. The board began to function promptly and is devoting attention to Lake Pleasant dam. The situation at that dam, which has been pronounced unsafe by several committees of engineers, was described in *Engineering News-Record*, Feb. 14, 1928, p. 75.

The act specifies that the board shall consist of five members to serve without pay—namely, the Governor, the state highway engineer, the state water commissioner, a member of the state tax commission and a member of the state industrial commission. This board is authorized to investigate any dam or reservoir in the state believed to be a menace to public safety and is empowered to proceed with abatement of such menaces under private contract on such terms and conditions as it may dictate, the work to be done under a competent engineer employed by the board. The entire cost of such work is to constitute a lien upon the dam, and if it is owned by an irrigation or electrical district the lien shall include all lands owned or controlled by that district.

The act also provides that the board shall not assume any contracts or bills for material "contracted on any dam or reservoir in existence at this time, but assumes authority only from the date this measure becomes a law." This provision appears to remove the prospect for reimbursement of those organizations that contributed to the fund with which the emergency enlargement of the Lake Pleasant spillway was begun in January.

$3,000,000 Bridge Planned to Span St. John Harbor

Definite announcement that the proposed $3,000,000 bridge to span St. John harbor, New Brunswick, is to be built shortly has been made by Mayor W. W. White of St. John. The modern steel structure which it is planned to erect to carry railway traffic and also tramcars, automobiles and other vehicles is one of the most important items in the development of St. John as a great seaport. The bridge will carry Canadian National trains from the present terminus on the east side across the harbor to West St. John, where extensive improvements are being carried out by the St. John Harbor Commission. The bridge will consist of two decks, the upper to be used for all traffic excepting steam railway. The bridge will be fitted with a draw section to permit passage of watercraft.

State Courts Must Hear Subway Fare Pleas for New York

Supreme Court Finds That Federal Courts Acted Improperly on Injunction

IN A decision on the long-pending litigation between New York City and the Interborough Rapid Transit Company over a proposed fare increase from 5c. to 7c. on the subway and elevated rapid-transit lines in the city, the U. S. Supreme Court in effect denied the company's demand for the higher fare. While concluding from the evidence before it that the present 5c. fare is not confiscatory, the court did not pass finally upon that point. It held that the lower federal court had acted improperly in issuing an injunction against the city's and Transit Commission's action opposing a fare increase. It therefore reversed the injunction order and remanded the case to the District Court.

The Supreme Court in its decision reviewed the case at length and made a number of observations of unusual importance in public utility regulation. The decision will be abstracted at length in a subsequent issue.

Head of Geodetic Survey Dies

E. Lester Jones, director of the U. S. Coast and Geodetic Survey for the past fourteen years, died at his home in Washington on April 9. Colonel Jones was born in East Orange, N. J., in 1876 and graduated from Princeton University in 1898. His first government work was that of deputy commissioner in the Bureau of Fisheries, chiefly on navigational and other needs of the Territory of Alaska. In 1915 he was made superintendent and director of the Geodetic Survey, which position he held continuously except for the period of his army service during the World War. He also served as commissioner for the United States on the International Boundary Commission, United States and Canada.

One of the principal achievements of his engineering career was the accurate charting of Alaska's coast line, which was an important step in the progress of that territory. Under Colonel Jones' supervision the Coast and Geodetic Survey has developed an exact and efficient organization for the coastal mapping, triangulation and precise leveling of the United States.

840-Ft. Building for New York

Plans for the new Bank of Manhattan Company Building between Wall and Pine Sts. in New York are reported to have been modified to increase the height of the building from 47 to 63 stories, or 840 ft. This height will exceed both the Woolworth Building, which is 792 ft. high and the 800-ft. Chrysler Building, under construction.

Irrigation Division to Meet at Dallas April 25

The Irrigation Division of the American Society of Civil Engineers will hold a meeting in connection with the regular spring meeting of the society in Dallas, Tex., on April 25. The program announced by the secretary of the division follows:

"Irrigation Problems in the Lower Rio Grande Valley," by E. L. Myers, consulting engineer, Dallas, Tex.; "Irrigation in Mexico," by Senor Ignacio Dancalari, director of Irrigation Commission of Mexico; "Silt and the Life of the Southwestern Reservoirs," by R. G. Hemphill, irrigation engineer, U. S. Department of Agriculture, San Antonio, Tex.; "Problems of the International Water Boundary Commission," by L. M. Lawson, International Boundary Commission, El Paso, Tex.

Fallen Bridge Span Undamaged

The lift span of the new Pennsylvania Lehigh Valley railroad bridge, which was reported last week as having fallen into Newark Bay from its temporary supports, is believed to have suffered only slight damage and can be lifted from its present position on the bottom of the bay. The span was supported on eight pile clusters at one side of the channel at a point where the water is about 20 ft. deep, waiting to be floated into place when the lift towers were completed. During the windstorm on the night of April 1 the pile supports collapsed, permitting the span to move sidewise and sink to the bottom of the bay. The span remained in an upright position.

Southern Pacific Ry. to Build New Line at San Jose, Calif.

In its annual report the Southern Pacific Company states that because of the expiration of the franchise by virtue of which the company operates along Fourth St. in the city of San Jose, Calif., the company will build a new line from College Park to Lick Station, a distance of 5.64 miles, ¼ mile shorter than the present line. The new line will have grade separation at eight points in order to avoid interfering with street traffic. The cost is estimated at $3,236,848. The work will be undertaken at once and it is expected to be completed within two years. A new passenger station will be built on the new line.

Further Railway Construction in Texas Proposed

The Kansas City, Mexico & Orient Railway Company of Texas, a subsidiary of the Atchison, Topeka & Santa Fe Railway, has applied to the Interstate Commerce Commission for authority to extend its line from Alpine to Presidio, Tex., a distance of approximately 85 miles. Recently the same company applied to the commission for authority to build an extension from San Angelo to Sonora, Tex., 65 miles.

San Francisco Automobile Ferries Authorized to Merge

Authority has been granted by the California Railroad Commission to the Southern Pacific Golden Gate Ferries, Ltd., to acquire the operative rights and properties of the Southern Pacific Company, the Northwestern Pacific Railroad Company, the Golden Gate Ferry Company, the Monticello Steamship Company and the Golden Gate-San Rafael Ferry Company, used in the transportation of vehicles, and their occupants, and freight contained therein, between San Francisco and various points on San Francisco Bay, and to issue 210,000 shares of no-par value common capital stock for the purpose of paying in part therefor. In addition to the stock authorized, permission is granted to the new company to issue and sell at not less than 95 per cent of face value, plus accrued interest, $10,000,000 of 5½ per cent twenty-year bonds.

The merger will result in the operation of automobile ferries on San Francisco Bay under centralized control and will do away with competition between the Southern Pacific Company and its subsidiary, the Northwestern Pacific Railroad, and the Golden Gate Ferry Company and its subsidiaries, the Monticello Steamship Company and the Golden Gate-San Rafael Ferry Company. This competition has been particularly keen between San Francisco and Sausalito, in Marin County. Heavy automobile traffic between these two points, especially in the spring and summer, first caused the Golden Gate Ferry Company to operate a fleet of automobile carriers in competition with the Northwestern Pacific.

Sewer Plan Embraced by Another Los Angeles District

By a vote of 304 to 99, County Sanitation District No. 8 of Los Angeles County on April 2 voted in favor of a $960,000 bond issue to participate in the metropolitan sewer plan. The district, which embraces East Gardena, Davidson City, Keystone and Watson, is essentially an industrial area, and it is believed that the sewerage of the district will facilitate and aid its development.

The district will participate in the use of the joint outfall sewer, part of which has been completed through the district, and also will use a part of the district No. 5 main trunk sewer which already has been completed. The remainder of the district can be served by relatively short trunks, the construction of most of which should be completed next fall.

The favorable vote in district No. 8 tends to solidify the entire project and fills in the gap between the several districts heretofore existing. There are left now to finance themselves only districts No. 3 and No. 7. District No. 3 probably will hold an election this summer. District No. 7 in the San Gabriel Valley was dissolved by recent election with the intention of creating a new district embracing a smaller area of communities which are favorably inclined to the system. It is possible that the new district may hold an election next fall.

Ohio Sanitary District Law Held Constitutional

The Ohio Sanitary District law, under which various water and sewerage projects have been and are being constructed, was held constitutional by the Ohio Supreme Court on March 27. The law was upheld successively by the Common Pleas Court of Mahoning County and the Court of Appeals before going to the Supreme Court. Suit was brought by two citizens and taxpayers of the Mahoning Valley Sanitary District, who claimed that the legislature could not delegate power and authority to levy taxes to an appointive body. The district named is engaged in providing a new source of water supply for the cities of Youngstown and Niles.

Detroit's Airplane Hangar Tangle Being Unraveled

Detroit's difficulties in getting under way the construction of an airplane hangar at its municipal airport have been settled by turning the work over to the department of public works. The proposal to construct a hangar came before the council in December, when it was decided to rush the structure in order that it might be completed in time for an aircraft show in April. Albert Kahn was recommended by Perry A. Fellows, city engineer, as the architect to have charge of the work. Mr. Kahn submitted a plan for a structure to cost $1,000,000, but the council rejected the plans and lated awarded the architectural contract to Louis Kamper.

In Mr. Kamper's first plan as submitted the cost was estimated at $2,500,000, and although this was revised downward several times it did not reach the original $1,000,000 estimate. Dissension in the council and politics held up the work and a solution has now been found only after several months of confusion. Mr. Kamper voluntarily released the city from the contract with him upon payment of the actual cost and overhead in preparing the preliminary working plans and specifications. The plans have been turned over to the city engineer, and it is stated that the city can also use all of the steel which has been fabricated under the former contract for the hangar.

Subway Franchise for Cleveland Turned Down by Council

The City Council of Cleveland, Ohio, unanimously voted down the proposal recently submitted to it to grant a franchise to the Peoples Subway Company to construct 75 miles of subway in Cleveland. The action was based in part on the fact that Charles H. Hubbell, the promoter of the scheme, declined to tell the City Council who was backing the proposition.

Opposition to Height of Proposed James River Bridge

Strong opposition has developed against the Richmond-Hopewell Bridge Company's proposed bridge across the James River at Varina, Va., and at a hearing held before Col. Henry C. Jewett, United States district engineer, the port authorities, the Richmond Chamber of Commerce and representatives of transportation companies in Richmond and Norfolk appeared to protest against the company's present plans for a span of 225 ft. with a vertical clearance of 100 ft. at maximum high water. Opponents of the bridge claim that it should conform to the plans by which the bridge at Newport News was built, this structure having a channel span of 250 ft. and a clearance of 147 ft.

Thomas G. Sydnor of Richmond, president of the bridge company, and B. J. Schuyler, of New York, representing the Highways Bridges Company, which is affiliated with the Richmond-Hopewell company, expressed the opinion that the bridge as at present planned would not interfere with the river traffic.

It is expected that a ruling by the War Department will be made within 60 days. The McClintic-Marshall Company, of Pittsburgh, has the contract for the construction work.

Amendment to Drainage Law Signed by New York Governor

Governor Roosevelt of New York has signed the bill amending the conservation law by enacting new provisions in relation to the powers and duties of the water power and control commission as to drainage and the maintenance and enlargement of ditches constructed under the former drainage law. The new law sets up a procedure very similar to the provisions of law relating to water supply, and provides among other things for the issuance of bonds at not exceeding 6 per cent interest.

Any person or persons possessing swamp, bog, pond, meadow or other low or wet lands, or any person or persons in the vicinity thereof, or any public corporation in which such lands are located, or in the vicinity of such lands, may present to the commission a petition praying for the formation of a drainage improvement district. Each drainage district shall be managed by a drainage improvement association.

Manager Plan Being Considered for City of Chicago

A bill now before the Illinois Legislature would make it possible for Chicago to adopt the council-manager plan of government—already in use in some Illinois municipalities. Under the proposed legislation Chicago would have a council of not less than fifteen or more than 50 members elected at large, by wards or by a mixed system, the exact method to be determined by an ordinance which would be submitted to the voters for approval.

Engineering Societies

CALENDAR

ANNUAL MEETINGS

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York; spring meeting, Dallas, Tex., April 24-26.

AMERICAN WELDING SOCIETY, New York; annual meeting, New York City, April 24-26.

AMERICAN ROAD BUILDERS' ASSOCIATION, Washington, D. C.; annual meeting, Washington, May 2 and 3.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston; annual convention, Memphis, Tenn., May 13-16.

AMERICAN SOCIETY FOR TESTING meeting, Atlantic City, N. J., June 24-28.

AMERICAN WATER WORKS ASSOCIATION, New York; annual meeting, Toronto, Canada, June 24-28.

AMERICAN ASSOCIATION OF ENGINEERS, Chicago; annual meeting, Mexico City, Aug. 26-28.

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THE HARVARD ENGINEERING SOCIETY will hold its annual meeting on April 25 at the Harvard Club of New York City. Allston Dana will talk on "Design and Construction of the Hudson River Bridge."

THE AMERICAN WELDING SOCIETY will hold its annual meeting in New York City April 24-26. On the tentative program is a symposium on how to organize and operate an industrial welding school, and papers on "Physical Properties of Butt Welds," "Welded Pipe Joints," "Design of Joints for Welded Steel Structures," "Welding in the Aircraft Industry" and "Thermit Welding of Rail Joints for Main-Line Track of Steam Railroads."

THE MID-SOUTH SECTION of the American Society of Civil Engineers, organized last fall, will hold its first formal meeting in Memphis April 29 and 30. The acting officers of the section are: president, S. C. Godfrey, Fort Leavenworth, Kan.; vice-presidents, J. H. Dorrah, University, Miss.; N. B. Garver, Little Rock, Ark.; Ned H. Sayford, Memphis, Tenn.; secretary-treasurer, A. S. Fry, Memphis, Tenn.

THE BUILDING OFFICIALS' CONFERENCE OF AMERICA will hold its 1929 convention at the William Penn Hotel, Pittsburgh, Pa., April 22 to 26. Members of the conference include executives of building departments of about 200 of the principal cities of the United States. The officers of the conference are: president, Robert Knight, deputy building commissioner, Chicago; vice-president, John Fowler, building commissioner, Jacksonville, Fla.; secretary-treasurer, John W. Oehmann, inspector of buildings, Washington, D. C.

THE ENGINEERS' CLUB OF OGDEN, UTAH, has completed its organization by the election of J. H. Young, president; J. R. Jarvis, vice-president; B. J. Truscott, secretary and treasurer; J. C. Littlefield, assistant secretary and treasurer. The object of the club is announced as the promotion of good fellowship, and service to the engineering profession and to the public. It is a purely local body. The present Ogden Chapter of the American Association of Engineers will continue to function, but as a separate organization.

THE NEW YORK STATE SOCIETY OF PROFESSIONAL ENGINEERS AND LAND SURVEYORS held its second annual meeting at New York City on April 3. Arthur V. Sheridan, New York City, wts re-elected president of the society and Arnold G. Chapman, Albany, and Edward A. Byrne, New York City, were elected vice-presidents. Speakers at the annual dinner were the president, Arthur V. Sheridan; H. N. Davis, president of Stevens Institute; James Sullivan, assistant commissioner, University of the State of New York; Willard Chevalier, president New York Section, Am.Soc. C.E.; and William M. Acheson, chief engineer, Department of Public Works, State of New York.

Personal Notes

R. L. SCHWING has left the Buffalo Floor Company, Buffalo, N. Y., and has accepted a position as engineer in the engineering department of the Metal Aircraft Corporation, Cincinnati, Ohio.

J. E. RIDER, formerly with the New York Edison Company, has joined the engineering organization of Gannett, Seelye & Fleming, Inc., and will be located in Buenos Aires.

G. H. KUECHLER will have charge of the branch office of Thomas E. Murray, Inc., designing and consulting engineers, of New York City, which has been opened in the Eaton Tower, Detroit, Mich.

M. P. MCCOY, of Okanogan, Wash., in charge of county highway work for several years, has been appointed engineer of Chelan County. H. F. EICHELBERGER, of Wenatchee, will succeed Mr. McCoy as highway engineer.

CHAD F. CALHOUN, of Los Angeles, formerly engineer for MacDonald & Kahn, San Francisco contractors, in their Los Angeles office, is now chief engineer for Fisher-Ross-MacDonald & Kahn, Inc., contractors building the $25,000,000 San Gabriel dam.

CLYDE R. ZEUNE, formerly deputy county surveyor, has been appointed county surveyor of Scioto County, Ohio, to fill the vacancy caused by the resignation of CHARLES NOEL, recently named division engineer in the Ohio Highway Department.

SAMUEL J. HUMES, Washington state highway engineer since May 1, 1927, has been appointed director of highways by Governor Hartley under the act passed by the legislature which abolished the old highway committee and established a department of highways directed by the Governor.

B. H. WITHERSPOON has been elected president and A. R. ELLIS vice-president in charge of operations of the Pittsburgh Testing Laboratory, Pittsburgh, Pa. Mr. Witherspoon was formerly district manager of the Remington Rand Business Service, Inc., in Los Angeles, Calif. He is a graduate of the University of Wisconsin. Mr. Ellis has been affiliated with the Pittsburgh Testing Laboratory since 1910, and has been general manager and director since 1921. He is a graduate of Cornell University.

Obituary

RICHARD BALDWIN, civil engineer, living at Waterbury, Md., died on April 3 in Baltimore. He was 63 years of age. Mr. Baldwin was for many years engineer on the Croton aqueduct, New York City. He retired from the engineering field some years ago to live on his farm at Waterbury.

CHARLES M. REDFIELD, chief engineer of the Central Oregon Irrigation Company, died on March 19 in Emmett, Idaho. Mr. Redfield, who was 58 years old, was educated in Albany College, Oregon, and the Albert Vander Naillen School of Engineering, San Francisco. He was engaged in railroad engineering work from 1889 to 1904, when he went with the Des Chutes Irrigation & Power Company and later in the same year with the Central Oregon Irrigation Company.

ROBERT BRUETTE POWELL, supervising structural engineer for Murray & Flood on the Lexington Water Power Company's Saluda River hydro-electric development near Columbia, S. C., died on March 11, after a brief illness due to injuries received in an automobile accident. Mr. Powell was 29 years of age. He was born in Fort Atkinson, Wis., and was graduated in 1923 from the University of Wisconsin. After graduation he entered the employ of the Dixie Construction Company of the Alabama Power Company on the Martin dam construction. In 1924 he accepted a position as designer, hydraulic division, of the Electric Bond & Share Company, remaining with that company until 1927, when he became connected with Murray & Flood.

EDGAR W. MALONEY, consulting engineer with Parsons, Klapp, Brinckerhoff & Douglas, New York, died at his home in Brooklyn, N. Y., on April 7 following an illness of several months. Mr. Maloney was born in Canton, N. Y., in 1883 and received his technical training at St. Lawrence and Cornell universities. After graduating, he was employed for two years on various engineering projects before joining the Board of Water Supply of New York City as an assistant engineer on the Rondout siphon in 1909. From that date until 1918 he was with the Board of Water Supply, first as an assistant engineer and then as a section engineer on shaft and tunnel work and on the Narrows siphon. In August, 1918, he went to Toledo, Ohio, as construction superintendent on the air nitrate plant and after a year on that work and two years in publicity work he joined the New York Water Power Investigation as a division engineer. Mr. Maloney was active in the organization of the Power Division of the American Society of Civil Engineers and served as its secretary from 1922 to 1926.

Construction Equipment and Materials

Tie Producers to Meet

The National Association of Railroad Tie Producers will hold its annual meeting at Hot Springs, Ark., April 23 to 25. The program includes a report on "Specifications for Ties for Industrial Track" and individual papers as follows: "Work of the A.R.E.A. Tie Committee," by W. J. Burton, assistant to the chief engineer, Missouri Pacific Railway; "Tie Requirements of the Electric Railways," by Howard H. George, superintendent of research, Cleveland Railway Company; "Railway Mergers as Affecting the Tie Industry," by E. T. Howson, Western editor of *Railway Age;* "Tie Producers and Tie Consumers," by F. C. Krell, forester, Pennsylvania Railroad; "Advantages of Uniform Tie Purchases," by R. S. Belcher, manager of treating plants, Santa Fe Railway; "Selective Logging in Tie Production," by R. D. Carver, forester, U. S. Forest Service. The secretary is Roy M. Edmonds, Syndicate Trust Building, St. Louis, Mo.

Business Notes

Butler Bin Company, Waukesha, Wis., manufacturer of steel storage bins, weighing and measuring hoppers, bin gates, etc., announces the appointment of the following new distributors: Arizona Road Machinery Company, Phoenix, Ariz.; General Equipment Machinery Company, Miami, Fla.; Hofius-Ferris Equipment Company, Spokane, Wash.; J. B. Harbison Equipment Company, Little Rock, Ark.; Loggers & Contractors Equipment Company, Portland, Ore.; Mechanical Supplies Company, Cincinnati, Ohio; W. T. McDonald & Company, Indianapolis, Ind.; New Mexico Road Machinery Company, Albuquerque, N. M.; Stannard-Arnold Company, Salt Lake City, Utah; J. C. Sheehan & Company, El Paso, Tex.; Tri-State Equipment Company, Memphis, Tenn.; Taylor Tractor Company, Columbus, Ohio; George V. Treen & Company, Charleston, W. Va., and Wiley Brothers, Inc., Oklahoma City, Okla.

H. A. Huebotter, formerly chief engineer of the Butler Manufacturing Company, Indianapolis, Ind., has joined the technical staff of the Waukesha Motor Company, Waukesha, Wis. From the time of his graduation from Purdue University in 1912 Mr. Huebotter has devoted his energies to automotive research, design and production.

A Large Merger of sand and gravel companies operating in the St. Louis territory has just been perfected with the consolidation of the Alpha Sand Company, the sand and gravel department of the Alpha Portland Cement Company of Easton, Pa., the Gravois Material & Supply Company, the Meramec Portland Cement & Material Company and the Ruprecht Sand & Material Company into a new company to be known as the Central Sand & Gravel Company. The new company, which will maintain its offices at 915 Olive St., St. Louis, will have an appraised valuation of $1,700,000.

Consolidated Rock Products Company, recently organized at Los Angeles, brings together under unified management properties of the three largest firms in southern California dealing in this commodity—namely, the Union Rock Company, the Consumers Rock & Gravel Company, Inc., and the Reliance Rock Company. The consolidating companies are reported to have annual sales totals exceeding 8,000,000 tons, which represents more than 75 per cent of the business in the territory served—that is, from Santa Barbara County on the north to San Diego County on the south and to San Bernardino on the east. The combination will own and operate 23 producing plants with a combined capacity of 4,500 tons per hour and 21 widely distributed bunkers with a combined storage capacity of 48,000 tons. The sand, rock and gravel deposits owned or under lease occupy 4,800 acres, from which it is estimated that the present rate of production could be supplied for 100 years.

New Developments

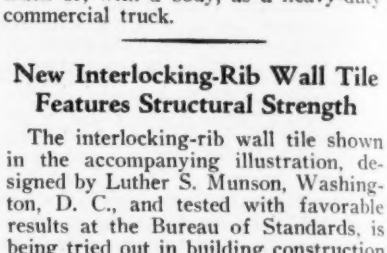
Street Flusher Fitted for Variety of Tasks

A street flusher which is eleven machines in one has recently been furnished to the department of streets of Gary, Ind., by the Four Wheel Drive Auto Company, Clintonville, Wis. In its arrangement, as shown in the accompanying illustration, the machine will wash pavements, fight fires, oil roads, sprinkle dirt roads, spray trees, plow snow, clean sewer inlets, empty flooded basements or stagnant pools, grade or maintain roads, haul garbage trailers and, with a body, may be used as a heavy-duty commercial truck.

The primary purpose of the unit is for flushing. A half-hour is required to install the snow plow blade on the frame provided at the front of the truck. The blade is manually controlled from the cab and is also suitable for road maintenance purposes. The resting jacks are provided on the flusher so that the unit may be uncoupled without delay and the truck used as a tractor truck or, with a body, as a heavy-duty commercial truck.

New Interlocking-Rib Wall Tile Features Structural Strength

The interlocking-rib wall tile shown in the accompanying illustration, designed by Luther S. Munson, Washington, D. C., and tested with favorable results at the Bureau of Standards, is being tried out in building construction preliminary to its manufacture on a commercial scale. The Research Service, Inc., of Washington, is handling its development. The new design has been developed to produce a more satisfactory wall material from the viewpoint of service in storms and earthquakes.



Munson tile is set up in double thickness, and interlocking is accomplished by dovetail projections on the inner faces. The dovetails are spaced to leave vertical keyways, which are grouted to form a monolithic wall. Since there is no mortar in the horizontal and vertical joints, the wall is not dependent on mortar strength in these planes as with some other types. The adjacent tiles are interlocked through the grout, which acts as a cushion and prevents the displacement

of tile when the wall is subjected to high lateral pressures or thrusts. This element is the new feature which is covered by patents. The dovetailing is said to be so designed that the tile does not bear diagonal tension or shear so that the mortar acts only in compression. By staggering the blocks, the wall is made practically damp-proof, since no joint runs all the way through.

High transverse strength was the principal feature brought out by the Bureau of Standards tests. The test wall would return to its original position after having been subjected to high transverse pressures under the breaking point. It was found that the tile made such a rigid bond that a single block could not be moved without shattering it entirely. Rapidity of construction and low labor costs are also claimed to be characteristic of the new tile.

New Publications

Power Shovels — ORTON CRANE & SHOVEL COMPANY, Chicago, Ill., has published a new bulletin, No. 60, on its crawler-mounted excavators. The first twenty pages of the 32-page bulletin are devoted to photographs and descriptions of the machine on different types of work, together with a discussion of the various advantages such as long and high reach, positive crowding action, high mobility and small over-all clearances. The second half of the bulletin is devoted to illustrations and descriptions of the various machine details, stressing and spring-type crawling tread, the electric-welded structural steel base and the worm-driven boom hoist. Dimensions, weights and working ranges are given for models A, G, T and W, which range in capacity from ⅜ to 1¼ cu.yd. Information is also given on the company's 35-ton model C crane.

Screens — MANGANESE STEEL FORGE COMPANY, Philadelphia, Pa., has published a 48-page bulletin entitled "Saving and Making Money With Rol-Man Screens," in which it points out that screen capacity, accurate sizing and long screen life have a decided bearing on tonnage output, operating costs, salability of the product and plant profits. The bulletin gives complete information on the application of the screens to revolving, vibrating, shaking and inclined-gravity equipment as used in various rock-crushing and screening layouts.

Atomic-Hydrogen Welding — GENERAL ELECTRIC COMPANY, Schenectady, N. Y., in its bulletin 823-D describes the arc welding equipment necessary to be used with the atomic-hydrogen method. The equipment shown is suitable for hand welding on 50- and 60-cycle circuits only. The process is explained, the equipment described and various parts of the apparatus illustrated.

Vibrating Concrete—ELECTRIC TAMPER & EQUIPMENT COMPANY, Chicago, Ill., has published two pamphlets devoted to the Jackson concrete vibrators, which it manufactures. The several types of machines shown include a "puddler" for use in placing mass concrete in dams, foundations, etc., as well as in slabs; smaller vibrators for vibrating thin sections such as reinforced-concrete pipe; and a somewhat heavier machine for use in reinforced wall sections and other places when difficulty is experienced in spading.

Cross-Connection Valves—JENKINS BROS., New York City, have published a new folder, Form 132, describing their Fire Underwriters' valves. The bulletin specially stresses the company's FM all-bronze swing check valves. The folder gives diagrams and illustrations of the method of installation. Generally the two check valves are installed between gate valves in a pit, so that they are accessible for examination and test. The check valves are also equipped with pressure gages and test cocks so that the tightness of each can be readily verified.

Asphalt Plants — MADSEN IRON WORKS, Huntington Park, Los Angeles, has issued a new catalog describing its portable paving plant for use in quantity production of all kinds of asphaltic paving. The bulletin describes the principles upon which portability of asphalt plants is based, gives the erection procedure, operating methods and a detailed description of the various component parts of the equipment.

Industrial Cranes — TRACKSON COMPANY, Milwaukee, Wis., has published a circular describing its new crane, which is built around a McCormick-Deering tractor. Photographs are included showing the use of the tractor on construction jobs, and in material yards and industrial plants. The lifting capacity of the various models varies from 1,500 to 3,000 lb.

Buckets — BLAW KNOX COMPANY, Pittsburgh, Pa., has published a new catalog containing complete data on its "Dreadnaught" type buckets. Each model is illustrated and described, after which the various component parts are considered in detail. These parts include the lever arm hinge assembly, the sheave bearings and head blocks, and the level arm sheave housing. Illustrations of the use of the buckets under various conditions are included, as well as specification and dimension tables.

Fire Pumps—CHICAGO PUMP COMPANY, Chicago, Ill., is distributing a new bulletin of sixteen pages, devoted to its single and multi-stage fire pumps. Typical layout diagrams are shown. The bulletin also includes booster and tank-filling pumps for high pressures. The company's ball bearing fire pumps have been accepted by the Underwriters' Laboratories. The bulletin is No. 104.

Metal-Handling Methods — CUTLER-HAMMER, INC., Milwaukee, Wis., has published a 28-page booklet devoted to the various uses of its "Red Top" lifting magnets. Photographs are used almost entirely to show the application of magnets to various kinds of work in foundries, junk yards, steel plants and miscellaneous industries. Several pages of text and illustrations describe the construction features of these magnets.

Gasoline Engines — WAUKESHA MOTOR COMPANY, Waukesha, Wis., has published a new bulletin entitled "What's New With Waukesha?" in which two pages each are given to its various models, ranging from the "Great Six" engine, rating at 200 hp., down to the 25-hp. direct-connected power plant. Each engine is illustrated and described. Curves of performance characteristics are given and dimension diagrams and general specifications complete the information.

Bituminous Distributors—GOOD ROADS MACHINERY COMPANY, INC., Kennett Square, Pa., has published a new catalog describing its bituminous distributing equipment. The various mechanical details of the company's "Champion" distributor are illustrated, described and discussed in detail. Thirty-six pages are devoted to this part of the catalog; the remaining ten are taken up with data sheets, tables of information and a specification of capacities and operating characteristics of the distributors.

Roller Bearings — TIMKEN ROLLER BEARING COMPANY, Canton, Ohio, has issued its first 1929 publication in the form of a 150-page book treating the general subject of the application of Timken bearings to all kinds of automotive, railway and industrial equipment and giving engineering information and data bearing upon the selection and choice of bearing types. In the first section of the book each type of equipment is considered in detail and analyzed with regard to its use of roller bearings. The second part of the book, containing technical information, covers such subjects as the design of the Timken bearing, the engineering service rendered by the Timken organization, methods of mounting and lubricating bearings and a series of dimension tables.

Power Shovels — UNIVERSAL CRANE COMPANY, Lorain, Ohio, has published a booklet entitled "The Story of a ½-Yd. Machine," a pictorial record of the history of the company's truck crane from its beginnings in 1917 to the present time, when it has been supplemented by the addition of a two-speed crawler-mounted center-drive shovel.

Portable Belt Conveyors—FAIRFIELD ENGINEERING COMPANY, Marion, Ohio, in its new bulletin, No. 66, devotes twenty pages to its various models of portable belt conveyors for handling sand, gravel, crushed stone, concrete, etc. The models are illustrated at work on the job, the illustrations setting forth several unique methods of material handling. Complete specifications and capacity diagrams are also included. Another new bulletin, No. 105, illustrates the Stearns-Fairfield idlers.

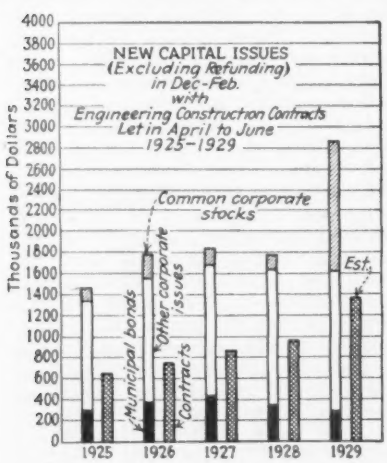
The Business Side of Construction

Why Construction Should Continue At a High Rate

THE high rate of contract letting in the engineering construction field, even when compared with last year's record, is now well known. The total for the quarter is $1,122,000,000, a gain of 42 per cent.

It is natural to expect that construction in April, May and June will be more active than in the first three months of the year. In 1928 it was 25 per cent more active, as measured by the value of heavy contracts. If the increase is the same in 1929, contracts in the next three months will total $1,400,000,000. Thus, if contract letting in the second quarter of this year steps up in the same ratio as it did in the second quarter of 1928, the total for the half year will be $2,522,000,000, or 44 per cent more than in the first half of 1928.

Can this observation be confirmed by other data? Comparing contract letting with issuance of new capital brings out some interesting facts. Contract value in the first quarter of 1928 amounted to 50 per cent of the capital (September-October-November, 1927); in the first quarter of 1929, to 55 per cent of capital (September-October-November, 1928). In the 1928 period capital was 28 per cent greater than in the 1927. Capital issued in December-January-February, just past, totaled $2,876,000,000, or 62 per cent more than in the corresponding months a year ago, thus warranting large expectations.



CONTRACTS WORTH $1,375,000,000 ESTIMATED FOR SECOND QUARTER 1929

Although these securities have actually been issued, a more conservative figure for estimating second-quarter contracts may be arrived at by examining the experience of several years. The percentages of contracts to capital have been as follows: 1925, 44.4; 1926, 42.3; 1927, 48.5; 1928, 56.1—reasonably even. In these four years the proportion has averaged 47.8. Using this figure as a basis, the contract total for the second quarter of 1929 should be $1,375,000,000 (see illustration). This is 23 per cent greater than for the first quarter. It will be recalled that the second quarter of 1927 recorded an actual contract value 25 per cent larger than the first quarter of that year.

Engineering construction contracts of the first half of this year may, therefore, be expected to reach a total of $2,497,000,000, compared with $1,774,000,000 in the first half of 1928. This is an increase of 40 per cent. The total for the year 1928 was $3,550,671,000.

E. N.-R. Index Numbers

	Cost			Volume	
Apr. 1,	**1929**	**203.40**	**March,**	**1929**	**382**
Mar. 1,	1929	207.78	Febru ry,	1929	378
Apr. 1,	1928	206.40	March,	1928	318
Average,	1928	206.78	Average,	1928	287
Average,	1927	206.24	Average,	1927	263
1913.....		100.00	1913.....		100

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of April 11, with some comparisons, total as follows:

(In Thousands of Dollars)

	Apr. 11, 1929	Apr. 4, 1929	Apr. 12, 1928
Building:			
Industrial.....	$6,711	$13,320	$2,850
Commercial.....	47,716	45,429	45,564
Streets and roads..	4,835	8,050	18,727
Other eng. constr.	20,650	25,932	14,787
Total.....	$79,912	$92,731	$81,928
Total, all classes, Jan. 1 to Apr. 11:			
1929.....			$1,294 585
1928.....			940,704

Week's Public Bond Issues Smallest This Year

This week's public bond offerings total $18,476,000, compared with an average of $26,000,000 for the first quarter of this year. The accompanying tabulation lists some representative offerings. The outstanding one is the $28,000,000 Arkansas highway and bridge 5 per cent obligations offered on a 4.75 per cent basis. This issue, handled by a syndicate comprising a majority of the larger distributors, is reported to be moving satisfactorily.

SOME CURRENT PUBLIC SECURITY OFFERINGS

	Amount	Interest Rate	Yield
Akron, Ohio, airport.	$384,000	4½	4.50@4.75
Allentown, Pa., school	850,000	4¼	4.15
Arkansas, highway and toll bridge.....	28,000,000	5	4.75
Asheville, N. C.....	950,000	6	5.25
Clifton, N. J.....	160,000	4½	5
Covington, Ky.....	300,000	4½	4.50
Herkimer, N. Y.....	622,000	4½	4.75@4.35
Los Angeles, Calif...	2,500,000	4½	5.00@4.65
	2,000,000	5	
New York City.....	60,000,000	Short term	5.25@5.75
Stickney, Ill. (Cook County), paving..	191,000	6	6

Residential Contract Curve Up

Contracts for residential buildings declined in value in November and December on about the same slope as they had the year before. The disturbing feature was that whereas February and March of both 1927 and 1928 registered a strong recovery, the decline in the early part of this year continued until last month. March shows an upturn of 28 per cent from February, but the figure is about the same as that for January, 1928.

VALUE OF CONTRACTS BY SECTIONS IN THE UNITED STATES AND TOTAL FOR CANADA, MARCH, 1929

Thousands of dollars (-000 omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States	Jan. 1 to Date	Canada
Water-works	$45	$632	$43	$1,792	$480	$476	$3,468	**$10,933**	.....
Sewers	181	1,885	874	1,459	1,500	131	6,030	**17,671**	$411
Bridges	25	1,981	327	1,107	1,293	251	3,844	**14,255**	.....
Excavations, etc	15	240	250	.....	438	846	1,789	**13,653**	.....
Streets and roads	687	3,547	2,472	3,416	2,831	3,790	16,743	**60,052**	295
Industrial buildings	3,910	5,843	10,165	5,351	1,592	2,607	29,468	**155,256**	2,535
Commercial buildings	9,479	142,800	9,258	25,352	17,151	13,421	217,461	**609,181**	4,150
Federal government	79	856	1,406	803	995	282	4,421	**16,935**	.....
Unclassified	250	23,532	16,845	1,555	17,525	730	60,437	**213,508**	6,250
March, 1929*	14,671	181,316	41,640	40,835	43,805	38,059	360,326	.....	13,641
February, 1929*	12,793	126,306	18,386	104,814	51,768	50,716	364,783	.....	14,107
March, 1928†	22,190	145,607	26,465	90,028	54,053	41,178	379,521	.....	22,394
Year to date, 1929	**54,537**	**463,980**	**80,979**	**197,960**	**196,150**	**128,338**	.....	**1,121,942**	38,995
Year to date, 1928	48,550	303,231	64,504	175,589	120,440	78,481	.....	790,795	39,713

*Four weeks. †Five weeks.